The Foundry Trade Journal

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Fraser and Chalmers' Engineering Works.

Visit by London Foundrymen.

On Saturday, May 15, the members of the London Branch of the Institution of British Foundrymen visited the Fraser and Chalmers Engineering Works of the General Electric Company, Limited, at Erith. The party numbered about 80, and was received and conducted over the works by Mr. F. W. Lewis (works manager) and the members of the works staff, amongst whom were Mr. A. R. Bartlett and Mr. A. Whiting (foundry department), Mr. MacKim (works chemist), and the foremen of every shop in the works.

After the cordial welcome which the firm extended to the visitors had been confirmed by a substantial repast in the works dining hall—a spacious and attractively decorated room—Mr. Lewis, on behalf of the general manager, Mr. E. Wilson, who was unfortunately unable to be present, expressed the pleasure of the firm and staff in welcoming the members of the Institution to the works. He spoke of the high educational value of such visits, and concluded with an appeal to the workers generally in the foundry trade to assist in the process of reconstructing the disorganised engineering and other industries of the country. The foundry trade, he said, was a basic trade, upon which practically every other branch of industry depended, and it was within the capacity of the foundry workers to greatly assist in the great work of reconstruction.

Mr. F. E. Pitts (President of the London Branch), in reply, tendered to the General Electric Company, Mr. Lewis, and the other members of the staff, the visitors' most hearty thanks and appreciation of the reception they had received in the works, and the hospitality shown to them. Although, as Mr. Lewis had explained, the works were still in the process of reverting to peace-time production, what the members had seen in the course of their visit was an eye-opener to most of them in respect to the possibilities of high-class engineering.

FIG. 1.—THE FOUNDRY OF FRASER & CHALMERS' ENGINEERING WORKS.

Major D. Gordon briefly supported Mr. Pitts' expression of thanks, which was heartily confirmed by the members of the Institution.

The following details of the departments inspected will be of interest to our readers.

The works cover an area of about 18 acres, situated close to the River Thames, within 14 miles of London. The shops comprise: Pattern shop, carpenter's shop, smithy, iron-foundry, boiler and plate shop, large machine shops for general engineering work, and turbine manufacture, making a very self-contained unit. The main offices are adjacent to the shops, and in normal times over 2,000 employees are engaged in the produc-

tion of finished machinery aggregating approximately 800 to 1,000 tons per month.

The power generating station is of up-to-date design and construction, the whole works being electrically driven.

The boiler house is equipped with water-tube boilers by Babcock and Wilcox, working at 175 lbs. per sq. in., fitted with chain grates. The coal is fed by an F. & C. belt conveyor into an overhead hopper, and it automatically descends by gravity into the furnaces of the boilers.

The turbine, to which is coupled direct a G.E.C. 1,500-kw. 3-phase, 50-cycle alternator at 3,000 r.p.m., is of Fraser and Chalmers manufacture.

There are two G.E.C. rotary converters, electrically coupled in parallel, running at 500 r.p.m., producing direct current at 440 volts. The switchboard and gear is also supplied by the General Electric Company, Limited.

The foundry, which was the first department inspected by the members, is composed of two main bays measuring 360 ft. by 155 ft., and situated approximately in the centre of the works and close to the main railway sidings. The entire length of these bays is covered by six 25-ton electrical overhead travelling cranes. The department is also well equipped with large and small jolt-ramming machines, also pneumatic moulding machines for repetition work, and sand-blast arrangements. The whole of the sand-mixing and other machines are electrically driven, and in addition to large core ovens Piftin hot-air mould-drying machines are also installed. It has been the policy of the company to provide for high-grade loam and sand castings up to approximately 35 tons weight.

In the foundry the members inspected a large variety of castings in different stages of production. Of considerable interest were the methods employed for casting in the blades of turbine diaphragms. Moulding machines in the equipment of the foundry include plain jar-ram and jar-ram turnover machines, power squeezers, hand squeezers, bumper machines, plain hand-ram and hand-draw moulding machines.

Besides moulding on machines in the ordinary way, as generally understood by the foundryman, several jolt machines were in operation, ramming cores in sand. Another very interesting feature of the core shop was the rotary core machines, these being in some instances driven by power, turning out cores from ⅜ in. upwards in straight lengths of 2 ft. without any reinforcement in the shape of core irons.

The boiler and plate shop has been specially arranged for the manufacture of boilers, mining plant, gas cleaning and conveyor plant structural work, furnaces, etc., and is equipped with pneumatic tools for caulking and riveting, in addition to the hydraulic presses and riveting installation. It is also provided with oxy-acetylene and electrical cutting and welding plants, and special machines for dealing with perforated plates and tank work, such as large shears, rolls, etc.

The general engineering shop is laid out for the manufacture of large steam and electrically-driven winding engines and air compressors, also fixed large steam engines for mill and factory driving, and various classes of mining machinery and general engineering. It has overhead cranes up to 25 tons, also large boring, turning, planing and slotting machines.

Adjoining this department is the works tool room.

Great interest was created by an inspection of the turbine department, which is equipped for the manufacture of large steam turbines, turbo-blowers and turbo-compressors. High-class machinery, such as boring and turning mills, planing machines, lathes, presses—for forcing the shafts into the rotors of turbines—balancing machinery, etc., is a notable feature of this section of the works. For the erection and testing of the machines before dispatch, a considerable number of test beds have been built with the necessary condensing plant underneath. On either side of this shop is a gallery, one of which is entirely devoted to the manufacture of blades for turbines, and here were seen excellent examples of accurate workmanship in the production of high-class articles.

The equipment includes many special machine tools, jigs, tools, etc.

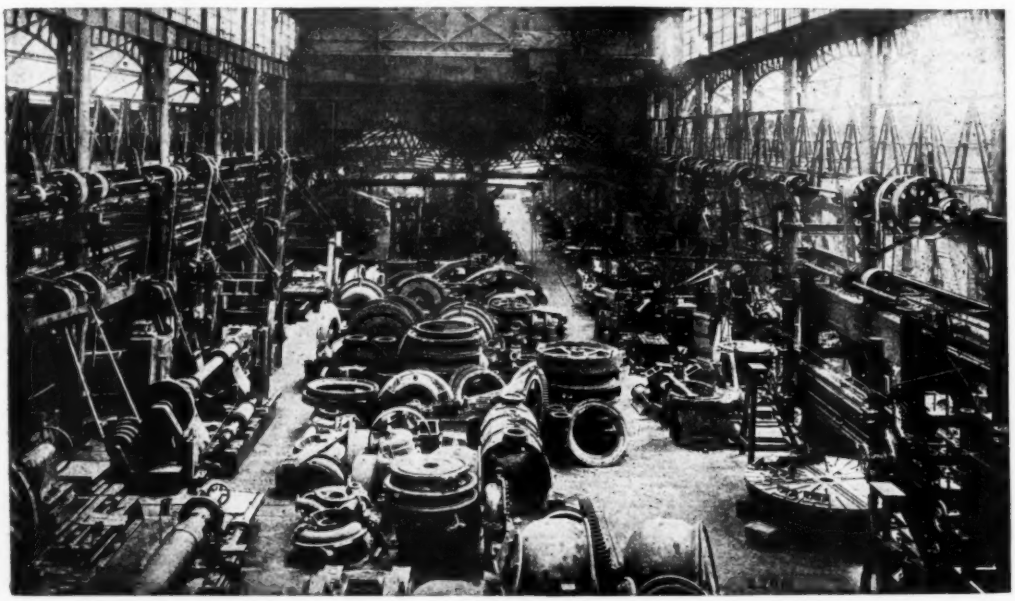

FIG. 2.—MACHINE SHOP NO. 1 CENTRE BAY; FRASER & CHALMERS' WORKS.

In the other gallery the assembling, riveting and finishing of wheels for turbines and blowers is done. Special electrical heating devices are installed so as to ensure satisfactory riveting of the bands on the ends of the blades.

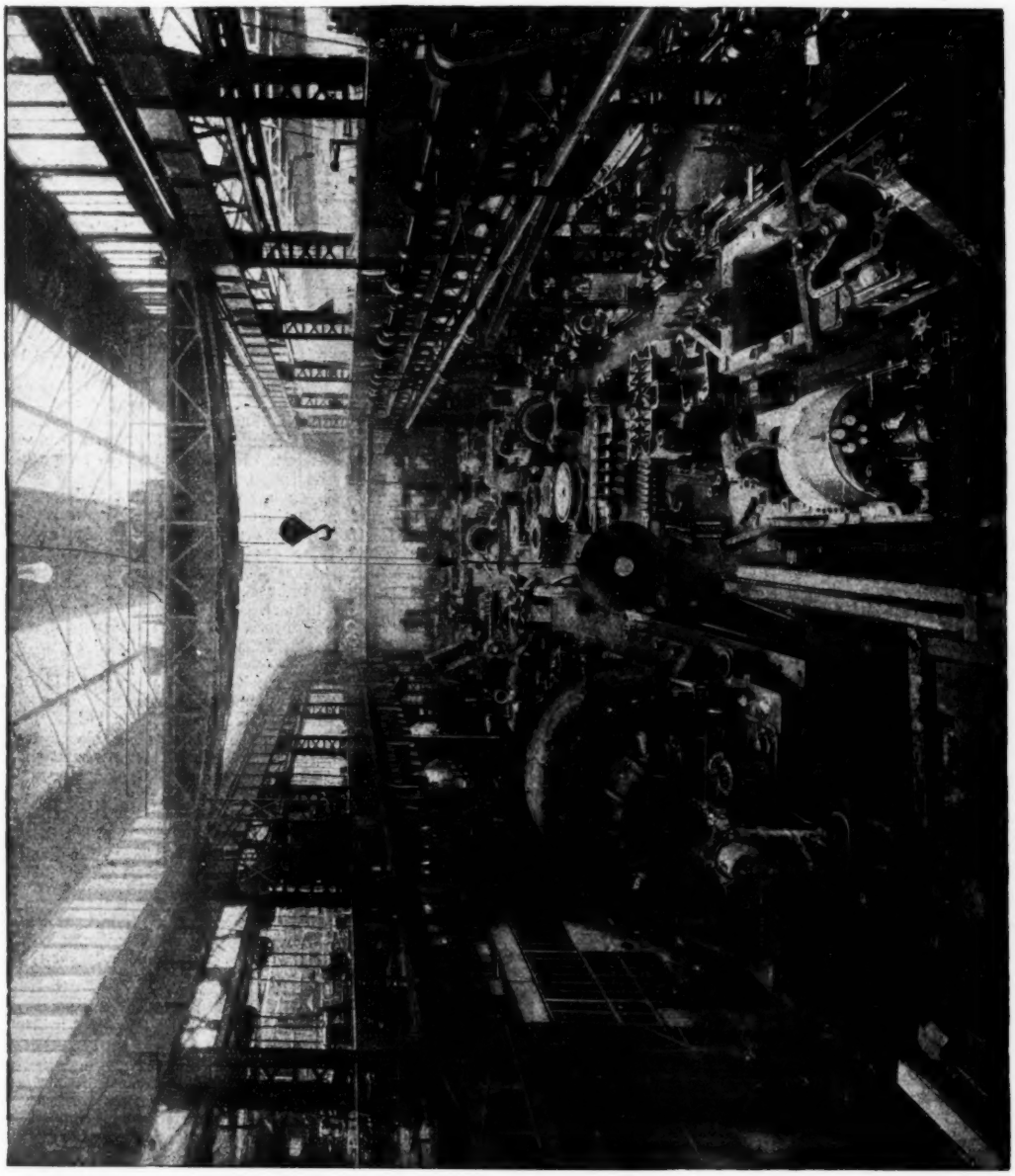

FIG. 3.—TURBINE MACHINE SHOP TEST BED AT FRASER & CHALMERS' ENGINEERING WORKS.

The smiths' shop is well equipped with steam hammers, sawing and cutting-off machinery, and is adjacent to the main general machine shop. This department has also an oil-fired annealing furnace.

The wood-working department is contained in a separate block of buildings, and comprises the carpenters' shop, pattern shop and pattern storage. The ground floor is occupied by the carpenters' shop, in which is installed all machinery, such as frame-saws, planes, mortising and other machines, necessary for the manufacture of mining and other plant.

The pattern shop is on the first floor, and adjoins the drawing office. It contains labour-saving devices, such as pattern-making machine, disc grinder, band saws, circular saws, and planing machines.

Close to this shop is the pattern storage; this is fitted with a very complete arrangement of racks, all numbered and a complete card index file is kept of all patterns. All departments are fitted with sprinklers in the event of fire.

A separate department is installed in the works,

fitted with the tools and machines required for the manufacture of belt conveyors, grab transporters, gas cleaning plant details, and idlers for conveyors, the demand for which has necessitated a new shop close to the existing building.

Finally, the visitors inspected the works laboratory and testing rooms, where demonstration tests were made on a Buckton transverse and tensile testing machine.

The concern of Fraser & Chalmers was formed as a public company in 1890, with the particular object of constructing works in the country for the manufacture of machinery for metalliferous mines and metallurgical works, based on American practice.

Work was commenced on the building in 1891, and the company were manufacturing on a small scale in the early part of 1892, finally getting well into running in the year 1893.

The later developments of the company were in connection with more or less allied lines, and in this direction they were very successful in developing the Rateau impulse type of turbine, and conveying, loading, transporting, unloading and handling plants, in both of which lines they were practically the pioneers in this country, as also in a later line of manufacture, when they introduced the dry gas cleaning plant for blast-furnace gases.

The General Electric Company, Limited, took over the works in April, 1918, and complete reorganisation from war conditions has now been made, with a view to concentration upon various special lines of manufacture, consisting of turbines, turbo-blowers, turbo-plants, mining machinery, winding engines, gas cleaning plants for blast furnaces, rolling mill equipment and general engineering. Considerable extensions are being made to the shops to make adequate provision for the ever-increasing call for the company's productions in these directions.

Messrs. M. J. Deville & Company, iron and steel merchants, have removed from Sheffield to 4, Bridgegate, Retford.

PYROMETERS.—We have received from Automatic and Electric Furnaces, Limited, 281-283, Gray's Inn Road, London, W.C.1, their Heat-Treatment Bulletin, No. 23, in which they point out that the chief causes of error in pyrometry are : (1 The indicator changes its calibration due to weakening of the permanent magnet. (2) The couple changes it constants due to a change in the alloy of which the wires are composed; but probably the greatest errors are due to sluggishness of the couple. Some tests have been made for sluggishness, and were carried out on two couples—one composed of wires 0.195 in. dia., the other of wires of 0.036 in. dia. Both were tested bare and again protected by a silica tube, the same tube being used in both cases. The smaller wire, unprotected, reached five degrees short of its final temperature in the first minute and attained its full temperature in three minutes. The larger wire took five and a half minutes to reach within five degrees of its steady temperature. When the couples were placed in silica, the small wire was 10 degrees short at the end of 14 minutes and was 5 degrees short of its final temperature at 18 minutes, while the larger wire when protected by a silica tube took 34 minutes to attain to within 20 degrees and 50 minutes to reach 10 degrees of the furnace temperature. The moral is that bare couples should be employed wherever permissible, but should a protecting tube be necessary, the wire selected should be as small as possible in diameter. We understand that the bulletins now circulate in no less than twelve countries, and it is desired that those on the mailing list who at any time change their address, should immediately notify the senders.

Microstructure of Iron and Mild Steel at High Temperature.

By H. S. Rawdon and Howard Scott.

In a recent issue of "Metallurgical and Chemical Engineering" the authors describe a method of demonstrating the structure existing in a metal or alloy at high temperatures. The method adopted has been previously described by other workers, including Tschischewsky, Rosenhain, Humphrey and others, and consists in heating specimens of the alloys to be examined to definite temperatures *in vacuo*. Experiments have been conducted on pure iron and mild steel, and the results are illustrated by a series of micro-photographs.

The authors arrive at the following conclusions :—

1. When polished metal specimens are heated *in vacuo*, a record of the structure existing at the particular temperature used is inscribed on the polished surface of the specimen. This record consists of a slight roughening due to volatilisation and to a slight "buckling" of the surface, due to the volume change accompanying the transformation. The terms "heat-relief," "heat-etching," and "vacuum-etching" have been applied to this method of developing the microstructure.

2. By means of heat-relief the structure of iron and steel at high temperatures is readily revealed. This is a much simpler method than the high-temperature etching often used. It appears probable that much of the effect usually attributed to etching at high temperature is due to the heating itself.

3. An appreciable change of composition and structure of the surface metal occurs in steel, upon heating. This is strongly marked just above the A_1 transformation, and becomes less so upon heating to higher temperatures, due to the increased rate of diffusion of carbon (as carbide) in iron. The structure revealed on the surface by heat-relief, or by high-temperature etching, is less representative of the interior at temperatures above the A_1 transformation than at any other temperatures.

4. The change in composition of the surface layer of steel heated to high temperatures *in vacuo* is to be explained as due to volatilisation of the carbide. No appreciable change takes place until the carbide enters into solid solution, *i.e.*, above the A_1 transformation.

5. The volatilisation of iron from the surface, upon heating, is very slight. Polished specimens of iron and steel, etched before being heated, retain the slight roughening due to the etching, even after pronounced heating. The volatilisation of iron at the crystal boundaries is more rapid than across the face of the crystal.

The report of the Stanton Ironworks, Limited, contains further details in regard to recent amalgamations. During the past year the company have secured for the United Kingdom and certain other parts of the world an exclusive licence from the International De Lavaud Manufacturing Corporation, Limited, for the manufacture of iron pipes through the application of centrifugal force, and a licence from the Hume Pipe and Concrete Construction Company, Limited, for the manufacture of concrete pipes and other concrete articles in the United Kingdom. At Stanton the necessary works to manufacture the pipes are being erected. The company have acquired the blast-furnace and foundry business of the Riddings Ironworks, near Alfreton, from Messrs. James Oakes & Company. Mr. James Oakes, the senior partner, has been elected to a seat on the board of the company. All the shares of the Oakwell Red and Blue Brick Company, Limited, Ilkeston, have also been acquired. Owing to the unsettled condition of the coal industry, the directors are unable to report any progress with the development of the new collieries in Nottinghamshire.

XUM

Drawbacks, Lifters, Rods and Nails.

By Joseph Horner.

The essential features of drawbacks, lifters, rods, and nails in that they form additional support or reinforcement to the sand apart from that provided by the moulding-box itself renders it convenient to consider these items under a single heading.

Drawbacks are often of considerable advantage, and by their use the clever moulder may often save much expense, time and labour in the shape of box joints, core boxes and dried sand cores, without incurring any more risk of inaccuracy than would be involved by the use of these more expensive methods. This particularly applies to jobbing work.

Fig. 1 illustrates a deep pattern, moulded in the floor. The shape is somewhat peculiar, and the same slope that is seen at the sides in section is imparted to the ends, but in exactly the opposite direction. In other words, the ends are sloping downwards, in the same degree that the sides slope upwards to the top. The casting is actually a portion of a machine for concrete mixing.

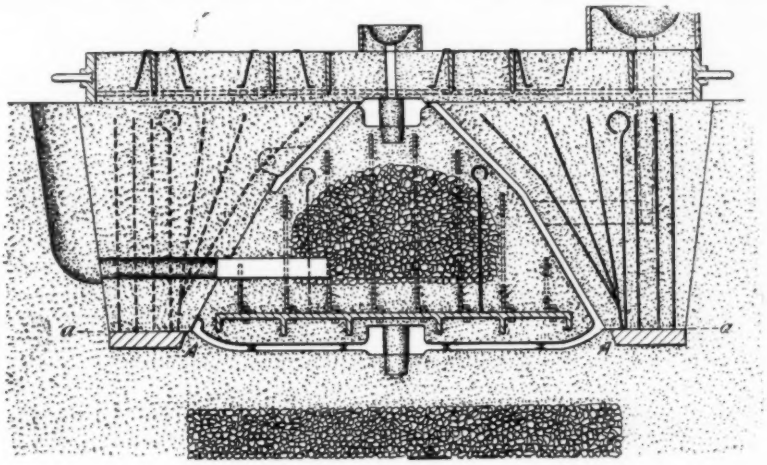

FIG. 1.

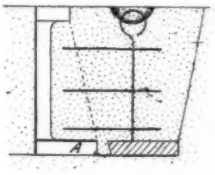

FIG. 2.

It is not possible, either to lift the pattern out of the bottom mould right away from the joint face of the core box, or to lift all the sand surrounding the pattern by a deep down-lift from the top, on account of the direction of the slope of the sides and the ends. Apart from this, a drawback is preferable to a deep down-joint carried from a top box into the mould in the floor, for in this case the sand would have to be carried down to the plane A-A, and supported wholly from the top on lifters, or on grids screwed up to the top.

If we consider the typical drawback in Fig. 1 we can see that if properly fitted it is as secure and accurate as the fitting of a top box part or of a core. A bed and a joint-edge A is made for it. The ends of the plated portion are bevelled so that the fitting of the three edges ensures the return of the drawback to its original position without any breaking down of the sand and risk of losing the register, such as would occur if the edges were square. Being set and adjusted to its position in the first place, it is rammed upon and vented in the usual manner. When the ramming is completed, the cope is laid on and rammed. This then being lifted off, the drawbacks are removed.

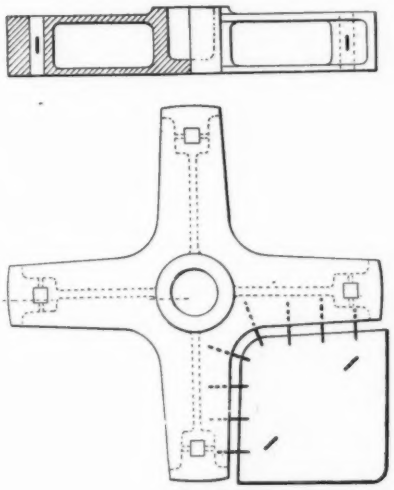

FIG. 3.

followed by the withdrawal of the pattern, leaving the lower part of the mould clear. This is mended, cleaned, and cored, and the drawbacks and the cope are returned in their order.

A common method of using a drawback, which is a

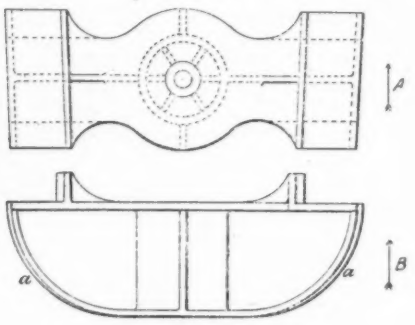

FIG. 4.

connecting link between the drawback proper and the grid, is outlined in Fig. 2. Here a solid continuous plate is made to surround a rectangular pattern of a crane bed, moulded in the floor, and covered with a plain top. The pattern is jointed, the bottom flange

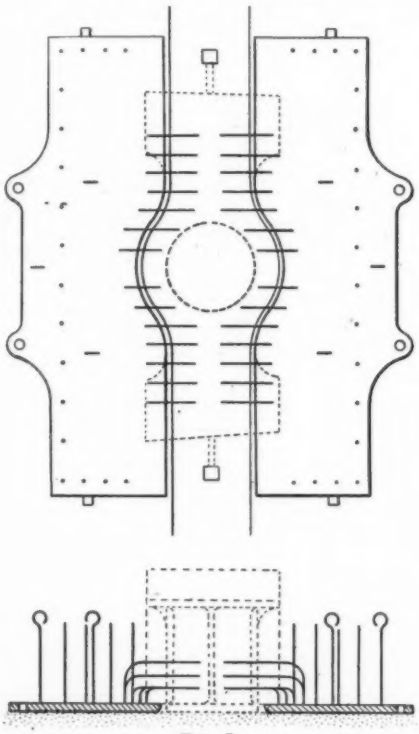

FIG. 5.

(A) being left loose, because that must remain behind until the sand which lies over it has been removed on the encircling plate. The method is accurate, and far less expensive than making so large a mould in a divided box, and turning over. The whole of the surrounding sand when lifted away can be got at for cleaning and the central portions of the mould are also clear for the moulder to work on.

Fig. 3 shows a cross casting for a crane foundation. The bottom flange is left loose in the pattern, and the sand above it is carried on four plates, one of which is shown. This differs from Fig. 2 only in the employment of separate plates.

The casting, Fig. 4, was made with drawbacks. Its peculiarity is the slope of the ends, imparted to correspond with two girders which it had to carry disposed in angular relations in plan. It is obvious that if moulded on its side in the direction of arrow A, although the outside would deliver, and the top, down as far as the central web, the portion below the web and within the end flanges could not be drawn, neither could the similar parts of the flanges on the girder face. A core box might be made, but the curved outlines would make it rather expensive. If moulded in the direction of the arrow B, drawbacks can be used, Fig. 5, and only the top flange with its brackets need be left loose. The whole of the space between the top and bottom flanges and the curved ends is made on the drawback plates, that are shown in position in Fig. 5.

In such a pattern as this, not turned over, measuring about 6 ft. in length, and having a broad underface,

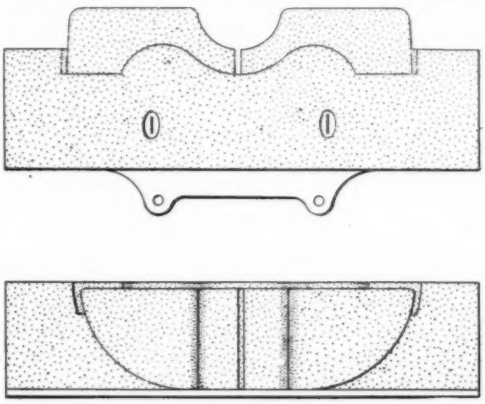

FIG. 6.

a coke bed is required to receive the bottom vents. This coke bed should be about 6 in. thick, with about 6 in. of sand between it and the pattern. The drawback plates are laid on a bed levelled for them, flush with the under face of the pattern, and about 1½ in. away from its edges. The locations of the plates laterally are fixed with the stakes as illustrated. It is usual in many drawback plates to cast prods all over the surface, these being short projections like those cast on loam plates. Long rods are often cast in to afford support to the deep sand. These rods are frequently bent over to carry the sand over the lower flange. An alternative to this would be the insertion of loose rods horizontally at intervals, in tiers, as the ramming of the sand proceeds. This is not so good and hardly so secure as the use of rods cast in. If used, they must be of ample length to come right back over the plate to counterbalance the mass of sand. The rods are wetted with clay wash and bedded in the sand, say, at 4 in. or 5 in. apart. When ramming the upper layers, care must be taken not to disturb the lower rods already bedded in by striking them with the rammer. Venting is done to the face of the pattern, and the ramming is done right up to the top flange, following the interior of the curved ends, and jointing with the outsides of the curved ends that are in the floor. The cope is put on, guided with stakes, liftered and rammed. On its removal, the upper

flange of the pattern is taken away, leaving the drawbacks and their moulds exposed. Fig. 6, ready to be lifted away from the body of the pattern, which is then delivered.

Another class of work is represented by the plan of a bracket, Fig. 7, and the section in Fig. 8. The pattern is not jointed along the middle plane, which involves moulding in a two-part box, and turning over. The bracket is about 5 ft. in length and only half a dozen were wanted, so bedding in was adopted, with

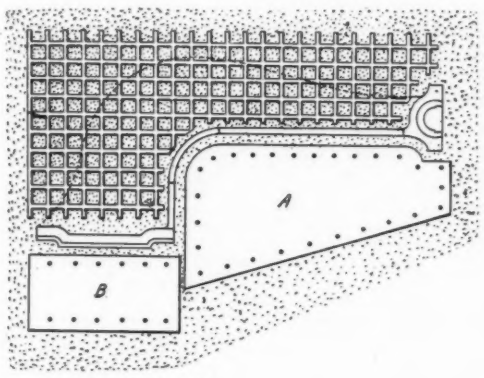

FIG. 7.

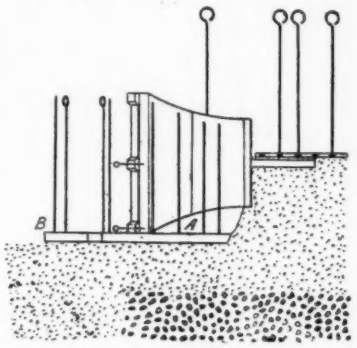

FIG. 8.

a pattern made solidly. The clear perpendicular faces of the bracket are carried on plates, A, and B with supporting rods cast in to confine the walls of sand. The lower side of the web is bedded in the floor sand. The upper side of the web is carried on a grid which is hung in the top box and screwed to it. An alternative would be to make a drawback plate to follow the outlines of the web in plan, and cast bent rods in it to come over the web, similarly to those in Fig. 5. One advantage which this method possesses over the employment of a divided pattern moulded in top and bottom box parts is that all faces can be got at directly for cleaning and blacking, while in the other case, the deep ribs are narrow spaces in the mould, in which the cleaner cannot be so easily manipulated.

In many moulds, there are masses of sand which cannot be adequately supported by the bars or stays of the boxes, and then lifters or gaggers are inserted. In standardised work, a great deal more can be done in sustaining awkward overhanging masses and corners of sand than in jobbing work, because the bars can be shaped to follow closely the pattern outlines. But here, in deep boxes, the use of lifters cannot be wholly dispensed with except by placing bars so closely together that the weight of the box would be unduly increased. In addition the case of loose pieces drawn in sideways, and flanged portions, where weak tongues and cods of sand require reinforcement, and where bars are not available should be considered.

As lifters have to carry the sand, they must themselves be supported, otherwise they would be liable to fall out of the box. They therefore rest on the top edges of the bars, Figs. 9 and 10, by their turned-round ends. They are turned similarly at the other end, to support the sand, both ends being alike, hence the term, S hooks, often applied to them. There is no particular arrangement observed in laying them in, except that which is best calculated to support the sand. They may be put thickly or thinly, vertically, or sloping. They must never be allowed to come into actual contact with the pattern anywhere, but should be set from ½ in. to ¾ in. away. If they touch, their impressions will show on the casting, and a blow may result.

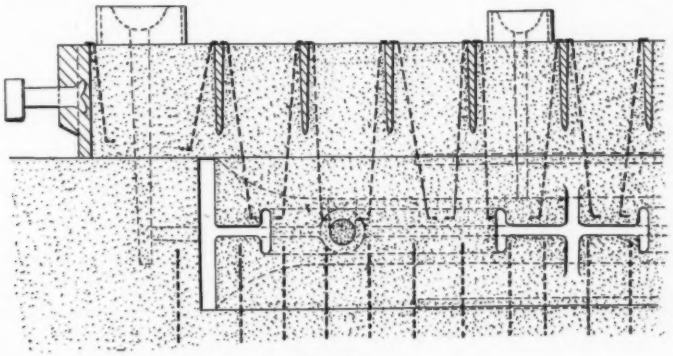

FIG. 9.

Lifters are not always hung from the top. Thus Fig. 11 rods are supported on the lower flanges of middle parts, destitute of bars, and lifters may be laid upon the rods, sloping upwards, and hugging the pattern closely. Lifters are usually cast, being moulded in quantities on a pattern plate in open sand. They may range from 6 in. to 24 in. in length. Lifters also are sometimes forged out in iron. Often the top hook forms a tee with the shank, instead of being L-

shaped. It gives the choice of two locations of attachment, so that the lower hook can be turned in either direction.

Figs. 9 and 10 also show the employment of rods to support deep masses of sand in bedded-in work. In this example, and whenever there are deep ribs separating masses of upstanding sand, these would become fractured without the support afforded by the

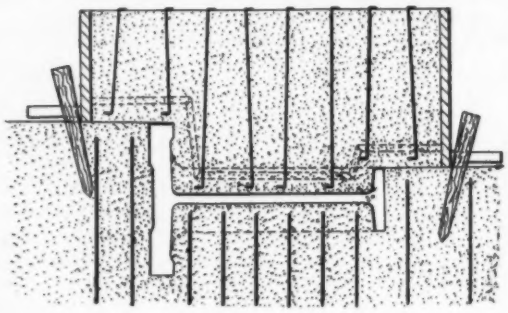

FIG. 10.

rods. These rods are driven down into the sand during the preparation of the bed, and they stop short of the face of the pattern by about 1 in.

Nailing concerns a more restricted set of conditions than the foregoing. In many portions of moulds, support is required to be afforded to some local area, where the sand happens to overhang, for

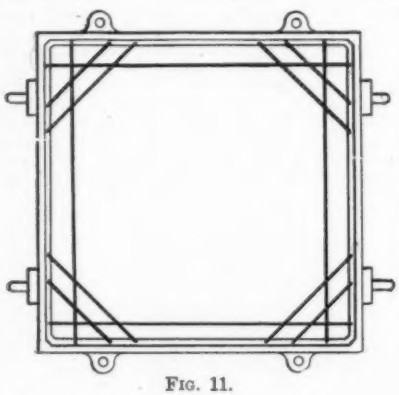

FIG. 11.

which grids and drawbacks would be impracticable, and rods too large. Nails afford the support necessary, being of small cross sections. As in loose rods, care must be taken to bring them far enough back into the main mass of sand to counterbalance, hence nails of different lengths are required. The nails are dipped in clay wash to secure the adhesion of the sand.

INDUSTRIAL FATIGUE RESEARCH.—The first annual report of the Industrial Fatigue Research Board, to March 31, gives an account of the activities of the Board. The Research Board was appointed in July, 1918, and investigations were accordingly instituted in the iron and steel, cotton, silk, laundry, and boot trades, and are now proceeding. In addition, research upon certain specific problems connected with industrial fatigue (such as fatigue tests, vocational selection, and motion study) is being conducted, irrespective of any special industry.

Effect of Various Elements on the Electrical Resistivity of Iron.

By A. L. NORBURY, M.Sc. (Manchester University).

(*Summary.*)

Describing his Paper as an attempt to co-ordinate the large amount of data which has accumulated since 1902, when Benedicks put forward his well-known formula for calculating the resistivity of a steel from its chemical composition, viz. :—

$R = 7.6 + 26.8 \times$ carbon (microms per centimetre cube)

the author proceeds first to summarise the most important papers published up to and including that of Benedicks in 1902. Stating that the pioneer work in this particular field was done by Mathiessen, in 1858-63, he remarks that part of his (Mathiessen's) work is often credited to Le Chatelier. The author points out that since 1902 Benedicks' formula has been generally accepted and utilised, although recently various investigators have indicated that its useful application is very limited. The author then deals with the results that have been obtained by recent researches into the effect of various elements on the electrical resistivity of iron, and in view of their direct bearing on Benedicks' formula he considers in succession: (1) The influence of carbon on the resistivity in annealed carbon steels; (2) the influence of carbon in quenched steels; and (3) the resistivity of pure iron. He then goes on to consider the influence of various other elements on the resistivity of iron, including nitrogen, aluminium, silicon, phosphorus, vanadium, chromium, manganese, nickel, cobalt, copper, molybdenum, tungsten, and gold, summarising the facts established by various investigators. The results are tabulated by the author (see Table I.), who points out that the values in column 7 show that equi-atomic quantities of different elements in solid solution in iron do not increase the electrical resistivity to exactly the same amount as conceived by Benedicks in his formula. It appears that a new factor, depending on the electronic properties of the particular element in solution, is determining the atomic resistivity increase in each case. From a diagram in which these values are plotted by the author, it is seen that where the two sets of values can be compared the relationship between them is quite good (with the exception of copper, which seems to have much too high an atomic resistivity increase value), indicating the probability that the atomic resistivity increase is closely related to the difference between the decomposition potentials of the solvent and solute. In confirmation of this supposition attention is drawn to the case of hydrogen. The decomposition potential of hydrogen being 0.0 and that of iron—0.4 volt, one would expect hydrogen in solid solution to have a very small effect on the electrical resistivity of iron.

Expressing his intention to leave the theoretical discussion of these results to a subsequent paper, in which it is hoped also to present some further data, the author passes on to the calculation of the electrical resistivity of a steel from its chemical composition, remarking that, so far as present knowledge goes, one should be able to calculate the resistivity of a steel by means of the results given in Table I., provided complications are not present, and provided that the amounts of foreign elements in solution are not too high.

The author summarises his Paper as follows:—

(1) A brief *résumé* of the most important papers on the present subject, up to and including that of Benedicks in 1902, has been given.

(2) It has been shown that Benedicks' method of plotting the resistivity values of quenched carbon steels on a straight line, and extrapolating to 7.6 microhms as the resistivity of pure iron, cannot be considered as correct in view of the results obtained by recent investigators.

(3) Recent determinations give 9.9 microhms per centimetre cube as the resistivity of pure iron at 20 deg. There appears to be no reason for assuming that this value is far from correct.

(4) An account has been given of the results obtained by recent investigators showing the effect of various elements on the resistivity of iron. These results (collected in Table I.) show that equi-atomic quantities of different elements dissolved in iron do not increase the electrical resistivity to exactly the same amount.

(5) A new factor depending on the electronic properties of the particular element in solution is determining the atomic resistivity increase in each case. This factor appears to be closely related to the difference between the decomposition potentials of the solvent and solute.

(6) The problem of calculating the electrical resistivity of a steel from its chemical composition has been briefly discussed.

(7) It is hoped to discuss these results more fully and present further data in a subsequent paper.

TABLE I.—*The Effect of Various Elements on the Electrical Resistivity of Iron.*

1. Author and date.	2. Element.	3. Atomic weight.	4. Increase in the resistivity of iron (in microhms per centimetre cube), due to the presence of 1.0 per cent. added element.	5. Temperature of measurement.	6. Column 3 multiplied by Column 4.	7. Increase in the specific resistivity of iron due to the presence of 1 atom added element in 100 atoms alloy.
Guillet 1914	Resistivity of pure iron = 9.90 microhms per centimetre cube at 20°.					
Yensen 1914	,, ,, ,, = 9.81		,,	,,	20°.	
Gumlich 1919	,, ,, ,, = 9.94		,,	,,	20°.	
Campbell 1915	Carbon*	12.0	34.0	20°	408	7.3
Braune 1905	Nitrogen	14.0	14.6	20°	204	3.6
Barrett 1902	Aluminium	27.1	11.1	18°	—	—
Portevin 1909	,,	—	11.7	23°	—	—
Yensen 1917	,,	—	12.0	20°	325	5.8
Gumlich 1919	,,	—	12.0	20°		
Le Chatelier 1898	Silicon	28.3	14.0	—	—	—
Barrett 1902	,,	—	10.3	18°	—	—
Burgess 1910	,,	—	12.0	—	—	—
Paglianti 1912	,,	—	13.0	15°	—	—
Yensen 1915	,,	—	13.0	20°	—	—
Gumlich 1919	,,	—	14.0	20°	—	—
Most probable value ..	—	—	13.5	—	382	6.9
D'Amico 1913	Phosphorus	31.0	11.0	—	341	6.1
Portevin 1909	Vanadium	51.1	5.0	—	255	4.6
Portevin 1909	Chromium	52.0	5.4	12°	281	5.0
Le Chatelier 1898	Manganese	54.9	5.0 (magnetic)	—	—	—
,, ,, ...	,,	—	3.5 (non-magnetic)	—	—	—
Barrett 1902	,,	—	5.0	18°	—	—
Lang 1911	,,	—	5.5	20°	302	5.4
Matsushita 1919	,,	—	5.5	30°		
Gumlich 1919	,,	—	5.0	20°	275	4.9
Portevin 1909	Nickel	58.7	1.5	—	—	—
Honda 1918	,,	—	1.5	30°	88	1.5
Honda 1919	Cobalt	59.0	1.0	30°	59	1.0
Burgess 1910	Copper	63.6	3.0 or 4.0	—	—	—
Ruer 1913	,,	—	4.0	—	254	4.5
Portevin 1909	Molybdenum	96.0	3.4 (approximate)	17°	326	5.8
Barrett 1902	Tungsten	184.0	1.1	18°	—	—
Portevin 1909	,,	—	1.5	15°	276	4.9
Guertler 1911	Gold	197.2	1.1	—	217	3.9

* Water-quenched at 1100°.

CONSIDERABLE progress has been made in recent months with the extension and further equipment of the Templeborough Works, at Sheffield, of Sheffield Steel Products, Limited, which will enable them to be in full operation shortly.

XUM

The Castings for a Condenser.—II.

By Ben Shaw and James Edgar.

THE MOULDING.

One of the most profitable means of producing the main portion of the condenser is to prepare the mould horizontally, adopting the roll over process for consolidating the sand in the drag. This method involves the preparation of suitable boxes, and in such foundries where stock sizes of box parts are maintained there is no difficulty in adopting this method.

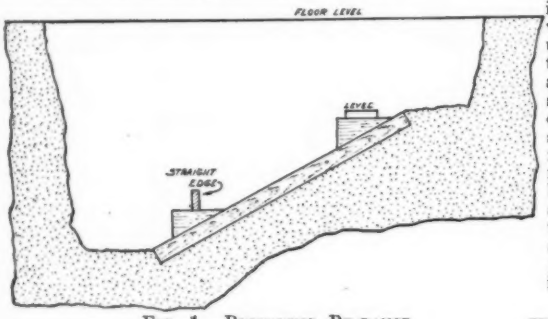

FIG. 1.—PREPARING BEARANCE.

The mould for this part might also be prepared in the foundry floor, and with suitable patterns and tackle "loam" moulding might be adopted. The general method adopted, however, is to prepare such moulds in dry sand and to utilise a pit, casting the mould either horizontally or vertically.

In the case of horizontal casting, considerable care must be given to the bed upon which the pattern is set. Since the bottom of the mould is inaccessible for ramming when the pattern is in position, it is preferable to prepare a special bed upon which the main part of the pattern will rest. In this particular case it necessitates a bed being prepared at an angle with the floor level and at a distance below it, which will allow the ordinary type of solid cope box being used. This frequently means that the highest part of the pattern will be just about floor level.

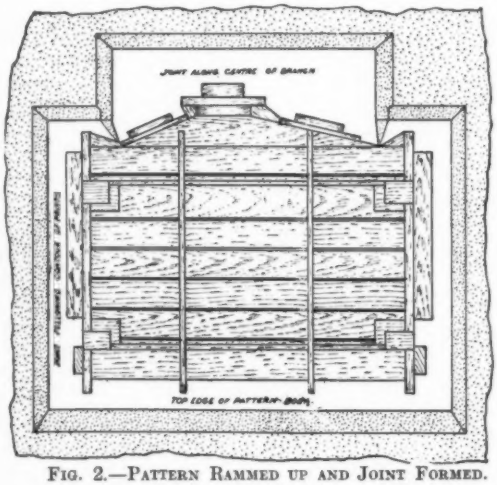

FIG. 2.—PATTERN RAMMED UP AND JOINT FORMED.

Difficulty is sometimes experienced in dealing with a raking bearance, and in the event of the pattern not being sufficiently rigid the resulting casting may be twisted. It is not a difficult matter to prepare a level bearance, and if the same principle is adopted in setting the logs for a raking bearance there will be less possibility of it being winding. To set the logs accurately temporary pieces should be fixed, cut to the rake necessary, so that when the logs are bedded in, as illustrated in Fig. 1, the surface edges of these pieces will be parallel to the floor level. A spirit level is used on the top edge of the pieces to set the logs with the requisite rake, and they also act as a support for a parallel straight-edge which can be tested with the spirit level until the logs are out of winding with each other, when the bed can be rammed up and strickled off. This provides quite a reliable bearance for the body of the pattern. When the logs are removed and the surface made up, the pattern should be lowered to get an impression of the end flanges and the ribs. On the pattern being raised the positions for these are loosened, some sand being removed and the pattern again lowered. This procedure usually gives a sufficiently definite impression of the projecting parts to allow the pieces being unscrewed from the pattern when it is again lifted, the pattern being located by the end flanges when finally lowered. When the pattern is set in position the sand should be rammed up along the deep side to avoid any movement along the rake of the bearance. It is well to remember that when forming vertical sides of deep moulds it is better to strengthen the sand by means of rods, set at intervals of about 3 in. or 4 in., and at right angles to the side of the pattern.

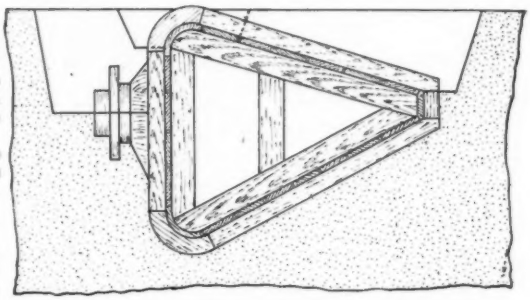

FIG. 3.—SECTION SHOWING RELATIVE POSITION OF JOINTS.

The first joint formed is that about the horizontal centre of the branch, and it should be large enough to give a reasonable bearance for a drawback which will take the impression of the upper half of the branch. Once this joint has been defined ramming can proceed, and a joint formed off the highest part of the pattern and prints through which the whole pattern could be withdrawn. A plan showing the joint made up is shown in Fig. 2, a section through the centre of the mould being illustrated in Fig. 3. All joints should be given a good level bearance and tapered well back to the floor level.

A plate is required to take the weight of the drawback over the branch when lifting. This should have a number of dabbers cast on the bottom, and a couple of staples for lifting. It is good practice to bed this plate into a covering of loam when commencing to make up the drawback.

Ram up the floor-level with sand, stiffening it over the branch by introducing a light semi-circular grid and making up the joint to coincide with the top joint already formed. The joint indicated would necessitate a considerable lift if carried in the top box; the alternative is to prepare another drawback to reduce the amount of lift, and to give better facilities when closing the mould for casting. The whole of the cover need not be taken with this drawback, but only sufficient to render the top lift comparatively simple. Again the practice of giving a covering of loam can be resorted to, and a grid having somewhat longer dabbers to carry the depth of loam might be used. When this drawback is rammed up and a joint formed approximately in the position shown by the dotted line in Fig. 3, the cope box can be set in position, staked, and a commencement made on the cover. Either small prods, secured to the box or gaggers alone may be used to carry the sand forming the lift, and the whole rammed up.

Probably the most convenient method of running such a job is by means of a spray along the narrow side of the condenser, risers being drawn from the highest points of the ribs and flanges, including the branch flange. This method has given satisfactory results. Whatever method of running is adopted it must be provided for when preparing the drawbacks and cope. When the cover is completely rammed and the gatesticks withdrawn it is necessary to lift it in order to remove the pattern. Having examined the stakes to make sure that there will be no difficulty in locating the box accurately, it can be lifted and supported on standards for convenience in cleaning. The cover drawbacks will then be lifted and supported temporarily. Precaution should be taken to remove the screws, and the sections of pattern work, such as the

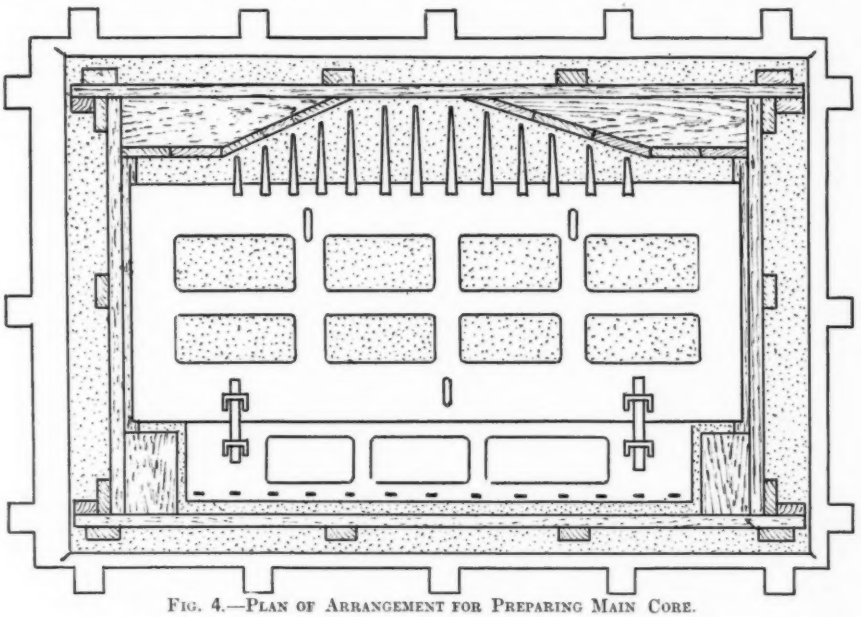

FIG. 4.—PLAN OF ARRANGEMENT FOR PREPARING MAIN CORE.

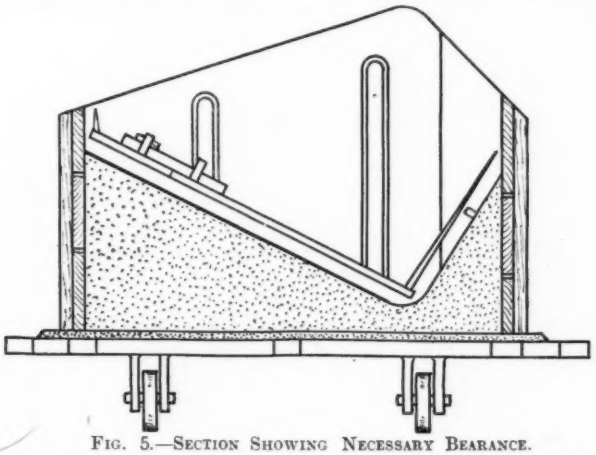

FIG. 5.—SECTION SHOWING NECESSARY BEARANCE.

flanges, ribs, and feet, will require to be lifted in each case.

The branch drawback when lifted will carry the top half of the branch pattern and subsidiary portions from the main body. The boxed section of the pattern is then clear and preparation is made for its withdrawal. corners of sand should be well nailed to give strength. The same procedure is adopted in connection with the drawbacks and cover. The runners require cutting, and the whole generally cleaned up preparatory to drying. In work of this kind, which must be dried in place, the drawbacks can be returned, and the cover

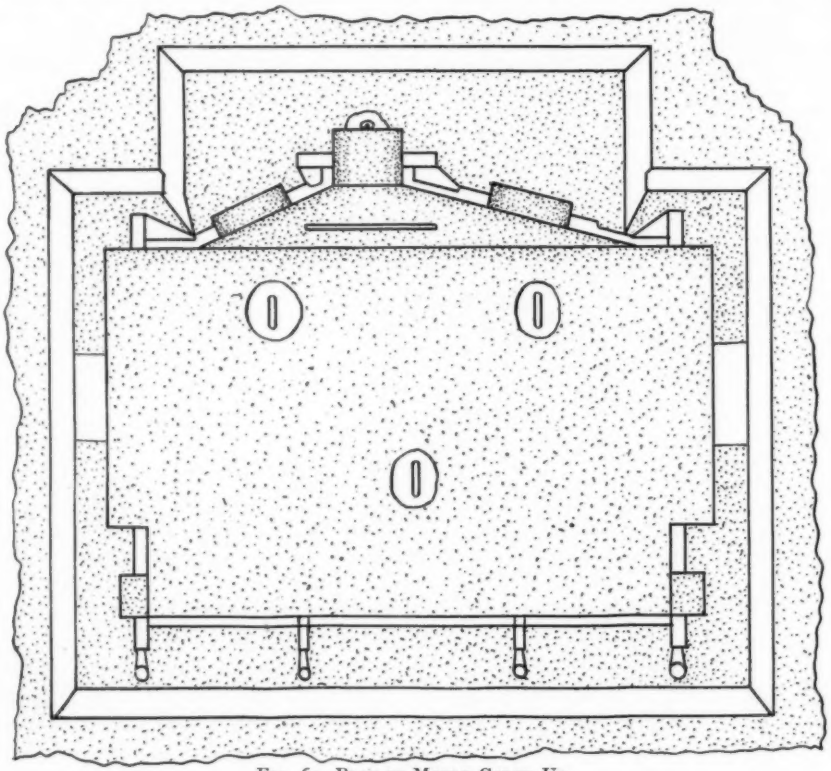

FIG. 6.—PLAN OF MOULD CORED UP.

It is customary to introduce lifting plates during the construction of the pattern at convenient places, either tapped plates for lifting screws or those having rectangular holes through, suitable for tee-lifting irons. They should be secured on the bottom, or very near to it for patterns of this character, so that the framework box supported over the mould so that all the parts are subjected to the same drying effect.

Cores.—A grid or plate is necessary for the main core, and this should be sufficiently strong to support the considerable weight of this core. A suitable type of plate for this core is shown in Fig. 4, it is made in

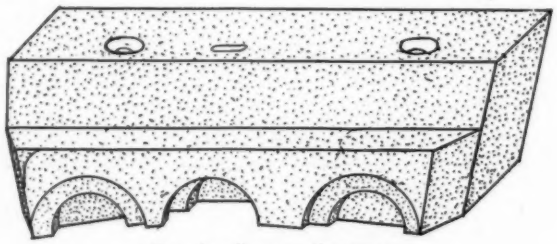

FIG. 7.—BRANCH DRAWBACK.

will take the strain when lifting. All subsidiary parts will be left in the mould, only the boxed section being removed in the first place. When this has been accomplished the whole mould requires to be carefully sleeked up, the sand cut away to form fillets about the ribs and flanges, and the small sections of pattern-work withdrawn. Parts of the mould forming fairly sharp two parts, which are secured by means of a wedged bar passed through staples. These bars can be conveniently removed and the plates drawn out singly when the casting is being cleaned. Cores of this description are usually made on a special core floor, adjoining a large core oven, and to facilitate the transfer of the core to the oven it is frequently made upon bogie plate, as

shown in Fig. 5. A loam bearance, usually dried, is prepared for setting the corebox level. Owing ot the particular shape of the core required, it is necessary to strickle up a bearance after the core box is set on the bogie, and for this purpose the loose parts inside the box are removed temporarily, leaving the guide pieces for shaping the bearance or cup for the core. The greater part is made up with bricks, and these are surfaced with ordinary floor sand being strickled off to

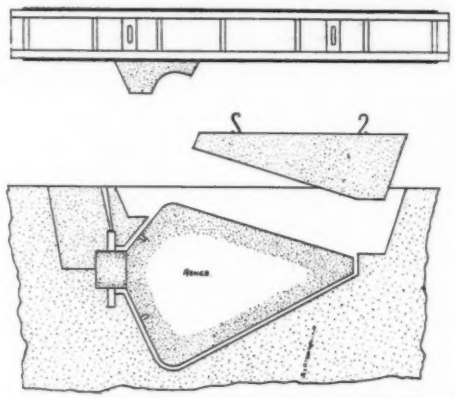

FIG. 8.—FITTING THE MOULD TOGETHER.

coincide, attached at each end of the box. When this has been prepared the construction of the core can proceed.

The bearance is given a good thickness of loam, into which the clay-washed plate is bedded. Bricks and loam can be used to form the shape, but if long prods or gaggers project from the outside of the plate and follow the contour of the core required, the use of bricks can be discarded, and loam merely used to form an outside shell introducing hard loam to stiffen the whole. Fairly large sized ashes require to be well rammed into the centre of the core, and the top made

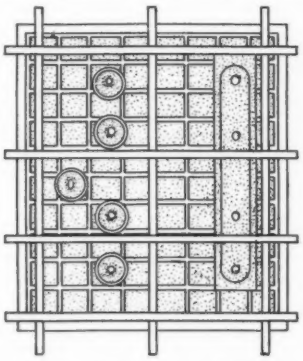

FIG. 9.—READY FOR CASTING.

up to a depth of about 5 ins. or 6 ins. with loam. It is the usual custom to leave the loam above the shape determined by the corebox until the whole become stiffened, when it is strickled off to the core-box ends. Fig. 4 gives a general plan of the core-box set on the bogie plate, the bottom shape of the core having been made up, and the core-plate bedded into its position, the loose parts of the core-box having been returned to their respective positions. A section through the branch connection is illustrated in Fig. 5. When this core has been strickled off, clearance is cut about the top of the lifting staples, and a commencement made to remove the woodwork. Providing the loam is stiff enough all the various parts of the core-box can be stripped from the core, the whole weight is taken by the shaped bearance upon which it is dried. During the process of stripping, the core should be sleeked over and corners rounded off where necessary. The smaller cores, including those for the feet, branch, manholes, and the two loose cores necessary for each

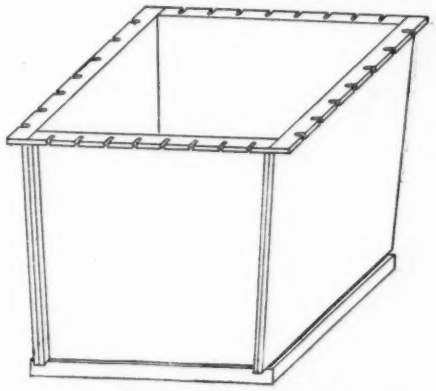

FIG. 10.—SPECIALLY CONSTRUCTED BOX FOR BEDDING INTO THE FOUNDRY FLOOR.

end of the condenser, are also prepared and transferred to the stove for drying.

When both mould and cores are dry, all parts with which the molten metal comes into contact are washed with blacking to prevent the metal fusing with the sand and give a good skin to the casting. Special attention should be given to the runners and risers, and the whole job thoroughly dried again.

The most convenient form of runner is one which will feed all the gates together, and since the metal is comparatively thin and covering a fairly large surface, it is preferable to prepare this runner so that stoppers can be used to prevent the mould obtaining metal until the runner is full. The riser basins can be separate ordinary circular boxes being used. In both cases these should be prepared and dried, and washed with blacking.

When all the parts are thoroughly dried the operation of coring up can be carried on. The small cores lightening out the back of the feet in the bottom are first located, and then secured with nails to prevent movement. Since these cores do not cut through, as a precaution against lifting, a double chaplet should be

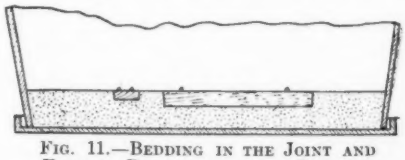

FIG. 11.—BEDDING IN THE JOINT AND FORMING BEARANCE FOR THE PATTERN.

nailed to each core. The manhole core in the bottom should project just the correct thickness of metal. The main core can now be lowered into position, and the ends should be free to the ashes and the mould eased away at the large prints for more ashes, to enable the gases generated when casting to escape easily. When this core is in its relative position the branch core can be set in, and if this core is a neat fit no other support other than that which is supplied by the print is needed. A contact can be made between the branch core and the vent of the main core. The other cores which can be set from the joint and indicated in the plan view,

XUM

Fig. 6, need no special fastening, but the small cores for the top feet require to be wired through the drawback so that their position will be maintained in an inverted position. It is necessary to make up the main core about the lifting staples, and care should be taken to ensure the sand being dried. Both drawbacks, one of which is illustrated in Fig. 7, can now be set, the

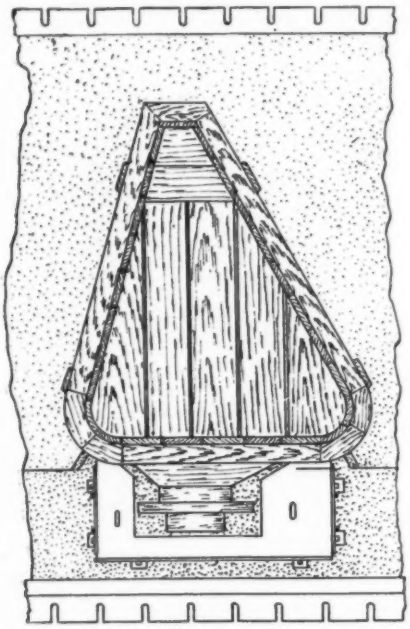

FIG. 12.—PLAN OF PATTERN RAMMED UP TO THE JOINT.

runners tested to make sure they are clear, and then the cover-box lowered. A section of the mould during the process of closing is shown in Fig. 8.

When the job is closed the runner and riser basins require to be grouted into position, and the whole box weighted down preparatory to casting the metal. A

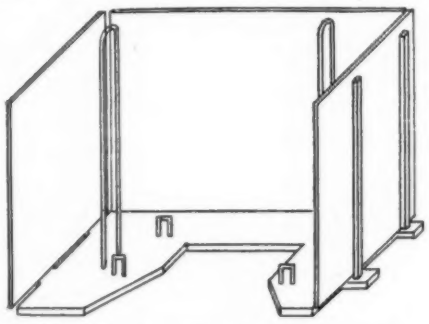

FIG. 13.—ARRANGEMENT OF PLATES FOR DRAWBACK.

general view of the method adopted is shown in Fig. 9. When a cast-iron case is used for bedding in such a job, additional means are adopted to restrain the lift of the cover-box when casting, by clamping the joint flanges, or better still when the flanges have a series of equi-distant slots, they can be bolted.

While the general form of the condenser lends itself to being cast in the manner indicated, many foundries prefer casting them vertically, and this preference is more in evidence in those foundries having what might be termed special cylinder cases bedded into the foundry floor. The greatest difficulty experienced is in the formation of the main core, since it cannot conveniently be made on its side, and then turned up on end, and be made on its side, and then turned up on end, and in the ordinary way. It can, however, be made nearer the foundry floor with a different form of core-box, and having a full bottom-plate introduced by which the core, built up in the same manner as a cylindrical core, can be lifted after the loam has stiffened sufficiently.

The making of the main core-box can, however, be avoided by what is known as thicknessing the mould and forming the core inside. The method has the advantage of giving a more regular thickness of metal to

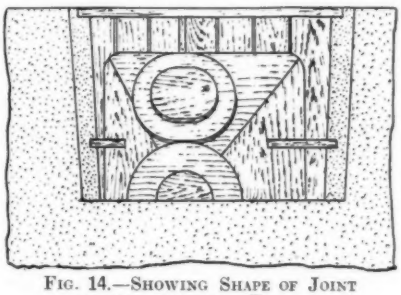

FIG. 14.—SHOWING SHAPE OF JOINT FORMED ABOUT THE BRANCH.

an irregular shaped casting, and can be applied to a condenser of this type. From an economical point of view the casting can be made cheaper when only one or two are required, but more time is occupied in the preparation of the mould for casting, since the same number of men employed in the method previously described cannot conveniently work when the core is made in the mould.

The type of case which is suitable for taking such a job vertically is illustrated in Fig. 10. It consists of four sides bolted together let into a bottom having an external flange, which can be sealed and made water-tight by ramming salammoniac and iron filings between

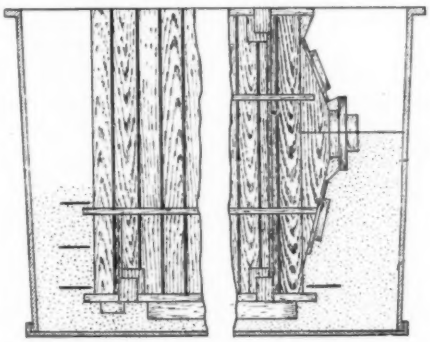

FIG. 15.—PATTERN SECTION REMOVED AND SET AS THE RAMMING PROCEEDS. SECTION OF MOULD SHOWING BRANCH JOINT.

the box sides and the bottom flange. The best types have tapered sides, so that the withdrawal of castings is not restricted. A stiff top flange is cast about the top having a number of slot holes cast through, as shown. A level bed is prepared at a depth from the top of the case equal to the height of the condenser body, and the pattern is lowered to get an impression of the prints. It is better if these prints are dowelled on,

as when their position has been located they can be bedded in separately as shown in Fig. 11, and the pattern replaced upon them—Fig. 15. The bottom flanges can be loosened and simply laid on the bed and against the body of the pattern, and a commencement made with the ramming up of the sand, the screws being removed from sections of pattern as the ramming proceeds. It is necessary to rod the sand directly over the bottom flange and over the horizontal ribs which surround the pattern. The sand can be rammed up in this way the full height of the job, and almost all round the pattern, with the exception of the branch. A joint is required to allow for the withdrawal of the pattern and to enable the core to be placed. It is better to level off the sand at the height of the branch centre over the full end of the case, and taper off the side joints as shown in Figs. 12 and 14. This enables the

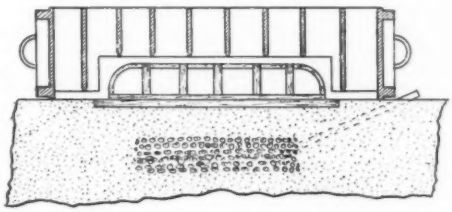

FIG. 16.—PREPARATION FOR MAKING COVER MOULD FLANGE DOWN.

drawback being made with the minimum contact with the mould. The type of carrying plate for such a drawback is shown in Fig. 13. Staples are cast in for lifting, and wrought-iron rods cast in snugs for supporting side plates, as illustrated. The back and side plates shown make the drawback independent of the mould, excepting at the face and bottom.

To carry the sand over the branch flange an additional grid is required and is secured to the bottom plate. In commencing the drawback a bed of loam is applied to the joint and the bottom plate set into it. Loam is also applied to the tapered points at each side to maintain a parting and prevent injury with the rammer. When the side plates are fixed up against

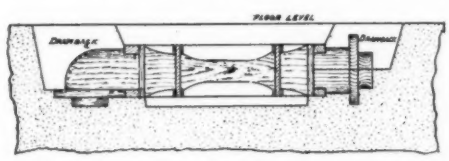

FIG. 17.—SECTION SHOWING THE JOINTS.

their supports the drawback can be rammed up, a small riser being introduced from the bottom of the flange. Small projecting parts of the rib, cutting through into the drawback, require to be cut for convenience in drawing. The cope in this instance is flat, and provision is made for pouring the metal directly into the mould. When the cover box and the drawback have been removed, the subsidiary parts remaining until the core is made. Strips of wood, equal in thickness to the metal required, are temporarily attached to the flanges and ribs, running the depth of the mould. The drawback is replaced, leaving the branch pattern in the mould. Ordinary floor sand is used to fill up the spaces between the strips and the main print is then withdrawn. In addition to the lifting plate at the bottom, a couple of ring plates should be used to strengthen the loam and bricks, as the distance from the bottom increases. The centre of the core is left open until the mould is fitted together for casting, when it is lightly rammed with floor sand. When the drawback is finally placed in position, the intervening space between it and the case is also filled with sand and rammed.

In preparing the mould for the cover, the method adopted depends largely upon the style of box available. As a rule, the flange is cast down, the pattern being bedded into the foundry floor until the uppermost part is flush with the floor level. Otherwise the flange portion is merely bedded into the floor as indicated in Fig. 16. When prepared in this way for casting, a bed of ashes must be formed under the job to allow for ease in venting. The skeleton construction of the pattern allows the ramming of the core to be done quite satisfactorily, the sand being carried to the outside of the pattern and strickled off. After the cope has been rammed, making suitable allowance for runners and risers, and removed, the surplus sand making up the pattern can be trickled out and the pattern withdrawn.

The core carried in the drag requires to be well sleeked over, the sharp corners of sand removed at each side of the ribs to form a fillet. The ribs can then be withdrawn and the facings drawn into the impression. A reasonable amount of care must be exercised in the withdrawal of these ribs and the facings, since the bottom is not accessible for patching. Some moulders prefer to cast the flanges uppermost, bedding the pattern into the floor until the top of the flange is flush with the floor level. This method necessitates a considerable lift in the cope, a grid usually being fixed to the cope-box to carry it. Dirty metal has a tendency

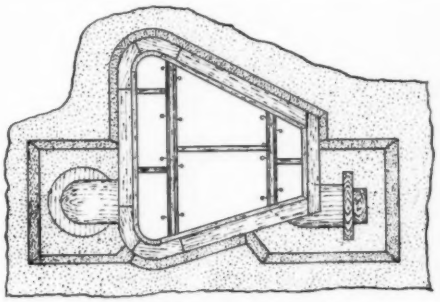

FIG. 18.—OUTSIDE RAMMED UP.

to collect on the face of the flange when the casting is poured in this way.

Several methods can be adopted in making the mould for the water end job. When the pattern for the main part is made similar to the required casting, the method of constructing the top and bottom flange usually decide the moulder in his choice. If both flanges are framed and used as a support to the shell pattern, obviously they cannot be drawn into the mould hence a joint must be made at both flange and the middle part either lifted in a box or taken away as a drawback. Even if the bottom flange is cut in such a manner as will allow for drawing in, this method can still be adopted, as in this case the core would then be left in the drag. While this method is used, it entails more work in providing a suitable mould, since a special large plate is required to carry the drawback, or a special type of box part must be used, and grids are also essential to strengthen the core. When the pattern work forming the bottom flange is in convenient sections, an alternative method of producing the mould can be adopted, which involves considerably less tackle.

When the foundry floor is used, as is usual in such instances, a shallow pit is required, having a depth which will allow a reasonable body of sand over the inlet and outlet branches.

The bed should be levelled off to allow the bottom flange to rest flat upon it, which necessitates the core print of one of the branches being bedded in. The division plates and ribs are temporarily removed from the pattern to allow a print being formed to conform

XUM

to the internal contour, and having a depth of at least 2 ins., as shown in Fig. 17. The cope remaining stationary, apart from drawbacks over the branches, the core must of necessity be made loose, and since it is not desirable that it should be divided into as many pieces as are indicated by the ribs, the print is made deep enough to take a lifting plate over the whole area, and strong enough to support the whole as one core. When the print has been cut out, loam is applied to the bottom, and a suitable grid, bedded in. The ribs and division plates can be returned to their former position, and the ramming up of the core proceeded with. All loose parts fastened from the inside must, of course, be detached as the work is proceeding. The outer part of the mould can also be rammed up, forming joints about the back of the flange on one branch and along the horizontal centre of the other branch, tapering them up to the floor level after forming a good bearance, in a manner shown in Figs. 17 and 18. When making the two drawbacks it is convenient to bed suitable grids in loam, and loam can be applied to the sand sides with advantage, because careless ramming sometimes injures these sides and interferes with the lift. The core will follow the lines of the ribs, the remainder being taken away in the cover-box, including the loose facings from the division plates. A casting of this description can be run successfully straight down by the side of the main core taking care to clear the cores of the branches, and greater satisfaction will be obtained if the impression of the top flange is curved.

When stripping has been commenced and the cover removed, the centre core can be withdrawn, and if a little taper has been allowed on the pattern it should not be a difficult job. The top flange can be left on the pattern to give support to the shell, and these also withdrawn. When the drawbacks are lifted the final stripping can be made, and the mould sleeked up. The moulds for both the cover and the water end are more satisfactorily made in dry sand, hence both moulds require to be dried and blackened for receiving the metal. With the exception of the cover for the water end, which should at least be skin dried, the remainder of the small casting necessary to complete the job can be made in green sand.

Mass Production in the Foundry.

In a recent issue of the "Electrician," H. W. Allingham deals with the question of mass production, of which a great deal has been heard during the last twelve months in the engineering trade, particularly in prospectuses. The idea has caught the public imagination—it has been put forward as the reason for the great accumulation of wealth in the U.S.A. It would be desirable for a moment to consider what should be meant by "mass production"—the meaning which is being applied to it in this country by company promoters and journalists is very different from the meaning it should carry.

We have in this country certain industries which have followed his idea of mass production for many years— since their inception in fact—such as the manufacture of chemicals, textiles, machine-made garments, boots, certain food products—e.g., margarine, etc. But the term mass production has never been applied to them, because it was not required. They are industries whose products were unsuitable for production by any other means.

There were several presumable reasons against applying exactly the same production rules to engineering work. First, our factories had grown from small beginnings, and there were numbers making the same products in competition, combines not being at all frequent. Second, our markets were not believed to be large enough to absorb enormous quantities of standardised articles. Third, we have always tended to change in design whenever research showed capabilities of improvement. Fourth, the tendency has been to meet the demand not to create it.

The country of large outputs in the engineering trade has undoubtedly been the U.S.A., and in that country the term "mass production" originated, coming to the forefront less than ten years ago; therefore, he thinks the definition of "mass production" should be based on the understanding of it there. Many definitions could be adduced, but one can be put alongside the many manufacturing programmes now being developed, and which can show them either in or outside the class: "Mass production" is manufacturing in such large quantities that the plant is laid out in the correct balance, and preferably in sequence, so that the work may pass from operation to operation consecutively. In general, hand in hand with mass production goes the special designing of the plant to carry out each operation in the most economical way, and machines are not changed over from one type of job to another, but are permanently set up for one class of operation only.

From the above it must not be imagined that mass production necessarily means that no changes are ever made. In the textile industries, for instance, mill work on specific orders, which vary one from another, but the main operations in any one mill are all the same, and the plant is in sequence and balanced. So also in such industries as the manufacture of soap or chocolate, buildings are such as to make the very best use of gravity, plant is specially designed for every operation, but changes from one variety of the product to another are not infrequent.

Such developments in engineering works in this country were very rare before the war, but it is many years since the author first saw examples in the U.S.A. In the works of one of the largest producers of gas fittings in Chicago, the brass foundry was on

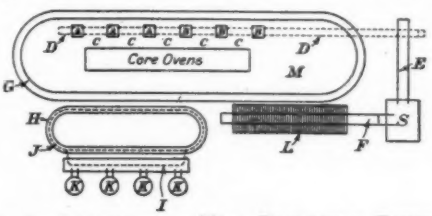

FIG. 1.—LAY-OUT OF A MASS PRODUCTION FOUNDRY FLOOR OF THIRTY YEARS AGO.

the seventh floor, the castings passing by gravity to the stores on the sixth. Gas cocks were tapped on the fifth, being delivered down a chute on to a pile alongside the machine which held the cock by compressed air, the two ends being tapped from the black casting. The output by one man on ¼ gas cocks was from 800 to 1,000 per hour. Upon the jaws opening, the cock body fell down another chute alongside the machine for reaming the taper hole on the fourth floor. The assembly was on the second floor, the finished stores on the first, with packing and despatch on the ground.

I was also much impressed with a large foundry having an endless travelling floor some 400 ft. long. It passed the moulding machines, between which there was space for the core-setters to work, and then came alongside another floor travelling at the same speed on which stood the men who poured the castings. Fig. 1 will illustrate the lay-out. These two examples are given somewhat in detail, as they are interesting in view of the fact that they have been in existence for nearer thirty than twenty years, and are further advanced than anything the author has so far come across in the engineering industry over here.

MR. C. H. WORDINGHAM, consulting engineer, has taken offices at 11, Mosley Street, Manchester.

Correspondence.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—Will you allow me, as associated with more than one Committee which is endeavouring to further the cause of industrial research in this country, to make a plea in your columns for greater activity in this direction, and to endeavour to deal with a few of the material requirements which this development involves?

Although some progressive firms are seriously taking up this problem the idea is still prevalent that scientific research, and the support of education in natural science, which it implies, are academic matters outside industry, and many of us have got to be convinced that research pays not only from a vague national standpoint, but in actual cash in any given undertaking.

At the present time, when prices are reaching the maximum which can be extracted, while wages still show an upward tendency, improvements in methods of output would appear to be the only hope of maintaining many industries on a sound financial basis, and if markets for our trade are to be preserved we must at least respect research as much as other countries with whose goods we have to compete.

Given a belief that science can help a particular industry—not difficult of acquisition if one turns to America or Germany—our slow progress would seem to be due to two main causes: one the pressure of the "daily round," which prevents those in authority from studying the subject; the other the disinclination to face the necessary financial outlay.

As regards the former, it need only be said that some competent person in the firm should be directed to investigate and report, and should be relieved of routine duties for this purpose; as to the latter, in a business of any magnitude the outlay necessary is comparatively small and should be faced in a far-seeing manner, not in anticipation of an immediate return, but in the light of an almost certain most generous recompense after a few years. Government grants are now available under certain conditions either in the form of money given to an approved Research Association set up by firms having common interests, or salaries to research workers for a term of years as "fellowships."

One of the main difficulties at the present time is that of building. As far as cost is concerned, the actual initial outlay in capital is not of such great importance as is often thought, inasmuch as the interest on this outlay is usually small, as compared with the annual cost in salaries and maintenance; at the same time, it may happen—and is, perhaps, particularly likely to happen just now—that it is easier to add a few hundreds to maintenance account than to provide a few thousands in the way of capital. Further, there is a real difficulty in getting buildings erected in a reasonable time, and prices are much inflated. It is none the less imperative that research is taken in hand more widely, and one of the main objects of this letter is to draw attention to the possible use of old buildings for the purpose. Processes and conditions change, and many factories possess old buildings, which might be utilised or made partly available by some re-organisation; again, necessary extension of works often produce available accommodation, and no building should be demolished before its possible utility for other purposes has been fully debated.

It may be truthfully said that a research building should be erected *de novo* for its purpose; at the same time when this idea is unattainable much work can be done in converted structures. Some of the best chemical research done at Cambridge twenty years ago emanated from a laboratory which had once been, the writer believes, a stable.

Researches must necessarily differ very much, but any scheme may be considered under the headings: Administration, statistics, pure science, and applied science, among which, or, perhaps, as a separate entity, the clinical consideration of the workers, upon which efficiency so much depends, might well be included. At the outset it should be realised that the scheme will be likely to grow, and hence possibilities of expansion should be considered unless the arrangements are to be regarded as temporary pending something better. As far as administration is concerned, for the modest beginning contemplated little will be wanted, but the director in charge should have an office, and a general office will also usually be necessary, which might often serve for the statistical section of the work as well. In some businesses a great deal of charting up of repetition tests may be required, but in all schemes great importance should be attached to extract work in order to keep the research staff up-to-date, save its highly paid time in hunting for information and put at its disposal the latest results of workers the world over. One person with a methodical mind and a general knowledge of science can, with a little clerical assistance, do a great deal in this direction, given access to suitable literature, and this work may well begin in advance of facilities for experimental researches. In this section also the work of the various sections would be co-ordinated under the director's instructions, both to keep the workers in touch with one another and to enable him to present reports embodying a complete practical issue to the heads of the firm. Pure science will require laboratories, according to the diversity and scope of the work, for chemistry, physics, biology, or other science with sufficient room to enable workers not to feel impeded and to prevent waste of time in taking down apparatus which may be subsequently wanted. Applied science will require accommodation of a shop type. Here experiments will be conducted on a commercial scale and the results of the laboratory will be subjected to the ordeal of practical working conditions.

To turn to material considerations, first, efficient lighting, heating, and ventilation are as necessary in a laboratory as they are now recognised to be in workshops; indeed, on more commercial grounds they are more necessary, as salaries are higher here, and any aid to efficiency will pay. A north or east light is best for laboratory work, particularly when microscopic investigations are required, and old buildings will often need more windows or top lights, but much can be done by suitable wall and ceiling treatment. If additional heat is required, rings of steam pipe near the ceilings are effective, cheap, and do not encroach on wall space, or in the absence of steam, low-pressure hot water, possibly accelerated by a small motor pump, is usually most suitable. Cross-ventilation by windows, though often effective enough in many rooms, must be supplemented by fans in laboratories for chemical and some other classes of work. As to treatment of walls and floors, so much of the former are taken up by fittings that a great deal of the costly glazed brick and tile work often found in laboratories is really quite unnecessary. Except round sinks and in fume cupboards, ordinary distemper is quite suitable, and if this is on bare brickwork fixing things to walls is facilitated. Even tiles may be obviated to some extent where distemper is unsuitable by the use of white cement trowelled to a fine face. For administrative rooms, biological, and even some physical laboratories, nothing is better for floors than good linoleum, which may be laid direct on cement, care being taken beforehand to make good any surface inequalities. Asphalte forms a comparatively cheap and very serviceable floor surface for laboratories and corridors, and can be laid on old boarded floors, which, however, must be well ventilated to avoid "dry rot." Terrazzo for corridors and wood blocks for laboratories are nicer, but more costly. Compressed cork again makes a beautiful floor, and has been used in America. If new cement (cheapest of all) is to be laid for corridors, it should always be made with granite chippings to avoid the otherwise inevitable wear and dust.

Laboratories, or at least those for chemical work, will require special drains. Wastes from the fittings should not be trapped, but discharged into open and

accessible channels, generally in glazed ware, but which may be quite effective in asphalte if organic liquids are little used.

As to fixed fittings, though delicate instruments require good cases, much simplification of the usual laboratory furniture might be effected when funds are limited. For example, fume cupboard bases of concrete finished in fine cement and well coated with resisting paint would be very serviceable, and such tops might possibly be used for working benches, which are usually, however, of teak, though tiles have recently been successfully adopted and enamelled lava is used in France, but is costly. The question of the simplification of laboratory fittings and the use of cheaper materials is being debated by an authoritative conference, and it is to be hoped that useful practical results may be the outcome. For actual research, as distinct from routine bench work, the fewer fixed fittings a laboratory contains the better. Gas, water, electric and other services should be confined in such rooms to narrow wall shelves or tables. Upon such fittings and the many other matters of detail many firms will possess scientists well able to advise, while in the initiation of a temporary scheme or utilisation of old buildings, here urged for an immediate beginning, a works foreman could often supervise the necessary alterations decided upon.

I feel that I must, sir, make an apology for a letter of so inordinate a length, and only hope that, having regard to the importance and great national urgency of the subject, space may be found for its insertion in order to direct the attention of your readers to a phase of activity in which early action can alone forestall very crushing competition from abroad in a few years' time.—I am, Sir, yours, etc.,

ALAN E. MUNBY.

9, Old Square, Lincoln's Inn, London.
July 14, 1920.

Electric Furnaces for Non-Ferrous Metals and Alloys.*

By VERDUN O. CUTTS.

The two principal requirements of a non ferrous metal furnace are (*a*) the generation of a heat as little in excess as possible of that which must be applied to the metal; (*b*) the desirability of melting such metals in a closed vessel. It will be obvious that both these features are essential if metal losses are to be kept low. The temperature of the electric arc is far in excess of that required for melting brass. Hence it is necessary, when using the direct-arc furnace, to interpose a protective layer between the upper electrode and the bath. In addition to this, the intense heat of the arc is severe on refractories. The same intense heat is present in the indirect arc furnaces, but in these it is applied to the metal by radiation. This type is, therefore, preferable to the direct-arc type in this respect. It is, however, equally severe on the furnace lining, probably more so. In fact, practical experience has convinced both designers and users of these furnaces that something must be done to protect the lining, or the difficulty and cost of retaining it in workable condition would prove prohibitive. The deflection of the arc is one device adopted to this end. Another and better scheme which has been adopted is the partial rotation of the whole furnace, which is made cylindrical in shape for the purpose.

Resistance Furnace.—The resistance type of furnace is capable of producing and applying just the heat required for the particular operation for which it is designed. It is therefore particularly suitable for melting metals and alloys which have comparatively low melting points and which volatilise readily.

A typical furnace installation consists of a cylindrical shell mounted on trunnions with suitable supporting brackets, and tilting gear which may be either hand or motor operated. This shell is heavily insulated with suitable refractories, the hearth being formed in the shape of a bowl and the roof being dome-shaped. An annular trough made of carborundum fire sand is supported on piers above the hearth. This trough is filled with a carbonaceous resistor material, the electrode connections to which are made by two graphite electrodes which enter the trough and furnace at points diametrically opposite. The working door is of the plug type, and provision is made for pouring without opening this. A ribbed cast-iron plate suspended from a counterweighted lever serves as an auxiliary door for the protection of workpeople when charging, etc. The underside of the roof ring is fitted with a fin which dips into a sand seal so as to effectively close the furnace. The control gear consists of a selective oil-break switch of simple design, by means of which any of the secondary voltages for which the transformer is built may be impressed through the furnace, each voltage giving a definite current input. The operation of the furnace is as simple as its construction. The heat is generated in the resistor trough and is imparted to the charge by (*a*) direct radiation from the trough which has a radiating surface of over forty square feet, and (*b*) indirect radiation from the domed roof and walls. The temperature gradient between the material to be heated and the point at which the heat is generated is less in this furnace than any other type of electric furnace. This permits of heavy heat insulation which makes for high thermal efficiency. The only parts of the furnace which need to be renewed regularly are the resistor material, the troughs, and the electrodes. The carbonaceous resistor material needs replenishing about once per fortnight when operating continuously. Electrodes and troughs have been known to work perfectly after six months' operation, but four months may be regarded as a minimum life for these under ordinary operating conditions. The nature of the furnaces enables a heat to be "held" without either superheating or freezing when circumstances render this desirable. The power factor of these furnaces is approximately 98 per cent., and the load factor closely approaches unity; thus offering an ideal load electrically. Electrical control and adjustment is rarely necessary; it is usually unnecessary to make any change in the current input for quite considerable periods.

When compared with other types of electric furnaces operating on similar mixtures and under similar conditions, the current consumption in these furnaces is relatively high. This, however, is a disability which is invariably compensated by the fact that resistance-type furnaces run with fewer stoppages and have a less chequered career generally. Another feature of resistance furnaces is that they are necessarily sluggish in operation. It is conceivable that this might prove a disadvantage and somewhat troublesome under certain circumstances, involving relatively long waits for substantial variations in temperature. This is a characteristic of all heavily-insulated furnaces, but it is a real advantage when it is desired to retain the heat of the furnace.

This type of furnace is now made in many standard sizes, ranging from 50 kw. up to 1,000 kw., of the pit, tilting, and tapping types. These several sizes are in regular commercial operation, melting brass, copper, zinc, aluminium, bronzes, etc.

The electric furnace has a wide range of usefulness in other branches of non-ferrous metallurgy and is, in fact, essential for the production of such metals as tantalum, which is a most interesting application. The adaptation of various types of electric furnaces for the melting of precious metals and the production of substitute alloys is one of considerable interest and value.

* Abstracted from a Paper read before the Birmingham Metallurgical Society.

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NOTES AND COMMENTS.

Steel Ingots.

Foundrymen in general will be interested to note the preliminary results of a comprehensive series of tests undertaken in America on steel ingots for rails made by Sir Robert Hadfield, under his special process of ingot casting. Preliminary details of the experiments which were undertaken in 1915 are recorded in a recent issue of "Iron Age." The complete results are to be published as a document of the Bureau of Standards.

The investigations have been carried out under the auspices of the Pennsylvania Railway Company and the American Bureau of Standards.

The experiments were made at the Maryland steel plant at Sparrows Point, Md., now the property of the Bethlehem Steel Corporation, under the direction of Dr. George K. Burgess, chief of the division of metallurgy of the bureau; A. W. Gibbs, as chief mechanical engineer of the Pennsylvania Railroad; and F. W. Wood, then president of the Maryland Steel Company.

Preliminary experiments in the use of sinkhead ingots led the rail committee of the Pennsylvania Railroad to purchase 100 tons of ingots cast by Sir Robert Hadfield in England. The Hadfield ingots were used to carry out comparative tests alongside the ordinary ingots of the Maryland plant.

"All ingots were rolled in 13 passes in a two-high mill to blooms 8 × 8½ in. The English-made ingots entered the blooming mill with the sinkhead toward the rolls, one-half receiving the first, or 'squaring up' pass in this direction, no draft being given on the second pass; while the other half were given no draft on the first pass, the 'squaring up' being done on pass No. 2. The Maryland ingots were rolled according to ordinary practice, entering the rolls the small end first.

"In the rail mill there are six passes in the roughing rolls, four in the intermediate rolls, and one finishing pass, making a total of 24 passes from ingot to finished rail.

"Each sinkhead ingot, of about 5,300 lb. weight and deoxidised with aluminium in the mould, represented a separate heat of converter steel. The comparison ingots, of 7,300 lb. each, were from three separate open-hearth heats, an intentional variation being made in the open-hearth and casting practice for each.

"The Hadfield type of ingot required a total discard of 18.4 per cent. on the average (13 per cent. top discard to eliminate piping and segregation above 12 per cent.), while the average ingot of the ordinary type for rails required a total discard of 43.9 per cent. (26 per cent. top discard), with great variations dependent upon furnace and ingot practices. The comparison ingots of non-deoxidised rising steel, chilled on top of ingot by cast-iron caps, required excessive discard to eliminate positive segregation at the top and negative segregation at the bottom of the ingot, the latter often accompanied by dangerous enclosed pipes. The second heat made of rising steel deoxidised with aluminium in the moulds, and the ingot tops of which were cooled with water, required the least total discard of the three heats. It was more subject to piping and less to segregation than the first heat of ingots made in the usual manner.

"The third heat made of quiet or 'killed' steel, was not chilled on top with water or caps, and was deoxidised with aluminium in the moulds. The ingots of this heat required an intermediate amount of total discard when compared to the first and second heats; this heat was the only one for which a greater top discard was required to eliminate piping than to eliminate segregation, about 12 per cent. One of the ingots of the third heat contained a small pipe at the bottom and all the rails from the middle and bottom of the ingots showed high negative segregation."

XUM

The Institute of Cost and Works Accountants.

The council of the Institute of Cost and Works Accountants have issued their report with the revenue account and balance-sheet for the year ending March 7, 1920. The report is very encouraging for the future and indicates a very successful first year's working. In spite of the many difficulties of organisation occasioned by post-war conditions, the membership has steadily grown, and in this connection it is very gratifying to note that the income during the three months immediately following March 7, 1920, is equal to the whole of the income for the year under review.

The Institute is to be congratulated on the acceptance of the presidency by the Right Honourable Lord Leverhulme, P.C., and also the following gentlemen as their vice-presidents:—Sir Robert Hadfield, Bart.; Sir Charles Wright Macara, Bart.; Sir Gerard A. Muntz, Bart.; Sir Herbert Austin, K.B.E., M.P.; Neville Gwynne, Esq., M.A.; W. Howard Hazell, Esq., J.P.; Henry W. Allingham, Esq.

For some time it has been realised that one of the chief necessities was the publication of an official journal, in order to keep members *au fait* with the doings of the Institute and in touch with the latest developments in the science of works accountancy and technical costing. At the same time it will provide a medium for the interchange of ideas, and, if properly used and appreciated, it will be of the greatest help to all. The Magazine and Library Committee, which has taken in hand the detail work in connection with the publication of this journal, are now well advanced with their efforts, and in a very short time the first issue should appear

The Influence of Phosphorus and Sulphur in Iron and Steel.

The joint committee of the several technical societies which is investigating the effect of phosphorus and sulphur in steel has started its work by compiling a complete bibliography on the subject. In presenting the bibliography the committee on statistics calls attention to the fact that nearly all foreign specifications allow a higher phosphorus and sulphur content in steel than is permitted in specifications originating in the United States.

Analysing the various opinions expressed in the papers reviewed, the committee states that it appears, although sulphur itself may be a detriment to iron if it exists as iron sulphide, its injurious effect may be neutralised by the presence of sufficient manganese to form manganese sulphide. This compound is said to be comparatively harmless unless it occurs in a segregated form.

Phosphorus is not believed to have decidedly detrimental effects in making steel brittle if the carbon content is low, although an increase of carbon content increases the hardness when both carbon and phosphorus are high and the steel is rendered brittle. Its effect also seems to be modified by the presence of other elements contained in steel. The form in which phosphorus is present also is said to have an effect on the properties of the steel. Stead's investigations lead him to believe that while Mn_3P_2 does exert a powerful influence on the mechanical properties of steel, the phosphide, if well distributed in the ground-mass, is practically without effect.

It also seems to be a generally accepted view of the various writers that these elements are the cause of segregation, and hence of unsound steel. Therefore, to reduce segregation the content of sulphur and phosphorus should be kept low. The "American Foundry" publishes a full bibliography of the various papers appertaining to the influence of phosphorus and sulphur on grey and malleable cast iron. These show that considerable difference of opinion still exists regarding the relative influences of these two constituents, and the need for further research with a view to obtaining more definite information is emphasised.

Season Cracking.

According to the Annual Report of the National Physical Laboratory, 1919, research has been carried out, and is still in progress, on the nature and cause of what is usually termed season cracking. In a preliminary account of the present research, given to the Royal Society in March, 1919, these phenomena are co-related by a simple theoretical explanation based on the theory that the crystals of a metal are held together by an amorphous cement. More recent work has shown that in the case of lead in particular, corrosion greatly accelerates the action, but it has also shown that corrosion is not essential to the phenomenon. The theoretical aspects of the work should serve to throw much light on the mechanism of internal cohesion in crystalline aggregates under various conditions

Mathematical Equations.

With a view of cheapening the cost of printing mathematical equations, and with a view to facilitating the reproduction of mathematical equations on the typewriter, the Concrete Institute have recently suggested that those writers who employ:—(1) The high point as the decimal separatrix (example 3·7 = 3 + seven-tenths); (2) the middle point as the sign of multiplication (example m.r = m multiplied by r); (3) the low point as the sign of abbreviation (example B.H.P. = Brake horse power), may avoid the use of subscript letters, and write the qualifying letters on the line of printing:—Example, m = Es/Ec, where m = modular ratio, Es = elastic modulus of steel, Ec = elastic modulus of concrete. The high point (or turned point) is the new British decimal point. (See treatise by Legros and Grant on Typographical Printing Surfaces.) The middle point is the usual sign of multiplication in American engineering text books and is also used in Germany. The low point, or period, is the international sign of an abbreviated word. If the above suggestions are adopted subscript letters can be eliminated entirely. These suggestions are intended to supplement the recommendations given in detail in the recently published report of the Concrete Institute on "Standard Notation for Engineering Formulæ."

Fuel for Motor Transport.

In the Interim Memorandum by the Fuel Research Board of Fuel for Motor Transport, recently issued, reference is made to the various sources from which fuel may be obtained. Regarding alcohol this is produced by fermentation from vegetable substances, and synthetically from calcium carbide and from the ethylene in coal and coke oven gas. None of these raw materials exist, nor can be produced in this country in sufficient quantities, or at prices enabling them to be used for making alcohol on a commercial basis. In the case of vegetable substances, of which the most suitable are grain (barley), potatoes and mangolds, the acreage is not available and, even if it were the present-day prices of all three render them prohibitive; the cost of the raw material alone for a gallon of alcohol would be 7s., 8s. 6d., and 3s. respectively. The quantities of waste wood are too small, the cost of producing calcium carbide where there is no cheap power is very high, and the extraction and conversion of ethylene is only in the experimental stage. The Report points out that in this country the natural source of heat and power is coal, and we have at present no alternative but to concentrate on the adaptation of its products for transport purposes. By recent developments in gasification practice 8 to 9 millions of the 30 millions of B.T.U. in a ton of coal have been obtained in the gaseous products, 3½ millions in the liquid products and 15 millions in the coke. The cost of 1 million B.T.U. in the form of petrol at 3s. per gallon is about 21s., being 2½ times that in gas and 14 times that in coke. In alcohol at 5s. per gallon 1 million B.T.U. would cost about 52s.

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Centrifugal Cast Piston Rings.

A new method of centrifugally casting piston rings developed by the Wasson Piston Ring Company, Planifield, N.J., is described in a recent issue of the American "Foundry."

Formerly, the common method of casting piston rings, especially the smaller sizes, was from a long, cylindrical pattern. This gives a casting, called a pot, from which a number of rings are cut in the machine shop. As may be seen, this operation involves considerable expense and in some shops it has been superseded by the method of casting each ring separately. The latter process involves a considerable increase in the expense of moulding, due to the proportionately large amount of sand and of gates and risers to the amount of metal in the casting. To lower the moulding cost the Wasson company decided to cast the rings in grey iron moulds, frequently known as permanent moulds. By this method, metal in the smaller rings became chilled. Some of the larger rings were not chilled when cast in a permanent mould, but enough of every lot were chilled, at least in spots, to make it essential that all rings be annealed before being machined. For this reason it was decided to study the effect of annealing. Some of the rings which were

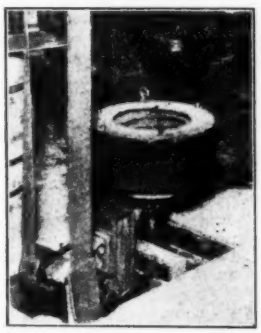

FIG. 1.—CENTRIFUGAL CASTING MACHINE. METAL IS POURED INTO THE CENTRE OF MOULD WHICH IS THEN ROTATED AT HIGH SPEED.

white, having been chilled through, were annealed. Although malleable iron, which is also a white iron, requires a number of hours to be annealed, this metal with its higher silicon content was found to reprecipitate out a large portion of its carbon on being heated a few minutes and allowed to cool in the air. Not more than ten minutes were required to cool the metal to a black heat when it could be quenched in water without deteriorating effects. While this treatment changed a large percentage of the carbon from the combined to the temper form and the metal became machinable, the annealed iron was not malleable and the hardness as determined by Brinell test was 250 or a little less.

An analysis showed the following composition : Silicon, 2.40 per cent.; sulphur, 0.104 per cent.; phosphorus, 0.65 per cent.; manganese, 0.35 per cent.; total carbon, 2.91 per cent. Practically all of the carbon was in the combined state when the metal was cast. After annealing, the iron contains 2.86 per cent. free carbon and 0.68 per cent. combined carbon. The free carbon is in the form known as temper carbon, and after annealing the sample has the appearance of malleable iron. Practically no ferrite is present and there is a far larger portion of pearlite than is found in malleable iron, owing to the higher percentage of combined carbon in the metal. This amounts to 0.70 per cent. on the average. Some rings of annealed iron were tried out in a gasoline engine, but did not prove successful because they lost their tension rapidly and wore excessively. It was concluded that the heavy wear was due to the rounded particles of temper carbon which did not give as good lubrication as the graphite found in grey iron.

The results of the first annealing tests proved so interesting that further experiments were made to determine the effect of different annealing times and temperatures on the hardness of the metal. The results of these tests were as follows :—

Time of annealing.	Temperature Degrees Fah.	Brinell after annealing.
1 min.	1850	250
1 min.	1850	250
3 min.	1950	241
5 min.	2000	238
45 sec.	1800	256
45 sec.	1800	250

The hardness of the different samples was so nearly equal after the foregoing anneals that it was decided

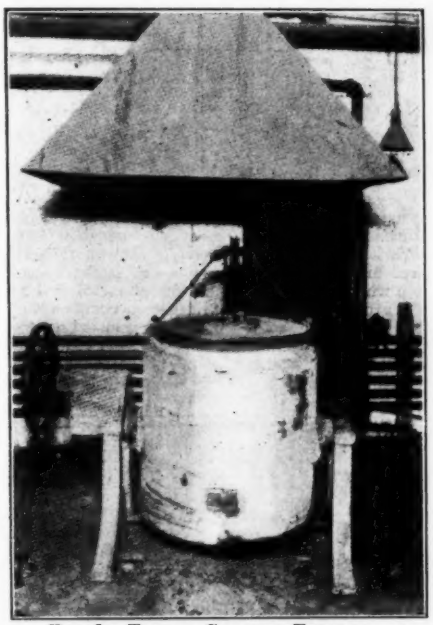

FIG. 2.—TILTING CRUCIBLE FURNACE.

to repeat the test, using greater variations in the time and temperature. This test gave the following results :—

Time of annealing.	Temperature Degrees Fah.	Brinell after annealing.
30 sec.	1800	242
45 sec.	1850	250
1 min.	1900	242
1 min. 15 sec.	1950	235
1 min. 30 sec.	2000	235
2 min.	2100	242
3 min.	2200	260

Chill May be Eliminated.

From the tests made by the Wasson Company it developed that chilled iron which is hard and contains almost all of its carbon in the combined state can be made fit for machining by annealing. However, the carbon separates out as temper carbon and does not give the iron the lubrication which is obtained when

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the carbon is in the graphitic form. This makes such metal unfit for use in piston rings. These experiments convinced the company of the impracticability of casting piston rings in permanent moulds.

One other method of casting piston rings seemed to offer encouragement. This was some form of centrifugal process. A small section of the shop was equipped to conduct experiments with this method. The results obtained were so satisfactory that the company decided to extend its operations along this line.

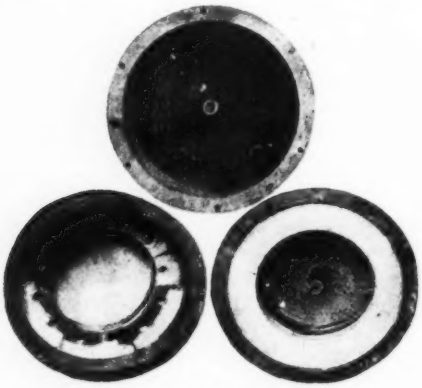

FIG. 4. FIG. 3. FIG. 5

The experimental department uses two crucible melting furnaces of the tilting type, furnished by the Monarch Engineering Company, Baltimore. These furnaces are heated by oil. The one is fitted with a crucible which will contain 180 lbs. of metal in a heat, while the other is somewhat larger, accommodating a crucible which will hold 450 lbs. of iron. Experience has shown that crucibles will last slightly more than ten heats, on an average. One of these furnaces is illustrated in Fig. 2.

This requires on an average a speed of 300 revolutions per minute.

To obtain the different variations from this speed a friction cone drive is employed. The variation of speed is secured by moving a leather belt along the cone. This belt extends around the rear, or driving cone. As this belt is moved toward the small end of the driving cone this cone must make more revolutions to turn the driven cone one revolution, and thus the speed may be varied. The cones are moved together to start the machine,

FIG. 6.—FOUR RINGS ARE CAST IN THE SAME MOULD—NOTE THE VERTICAL RUNNERS WHICH ACT AS FEEDERS.

and the belt around the driving cone is thus pressed against the loose cone, which it drives by friction. Five sizes of cast-iron flasks are employed. In the smallest one, rings are made from 8 to 12 in. in diameter; the second size is used for rings from 12 to 15 in. in diameter; the third for rings from 15½ to 17½ in. in diameter; the fourth for rings from 18 to 22 in. in diameter, and rings from the largest size flask range from 22 to 29 in. in diameter. An empty flask is shown in Fig. 3. To make the mould

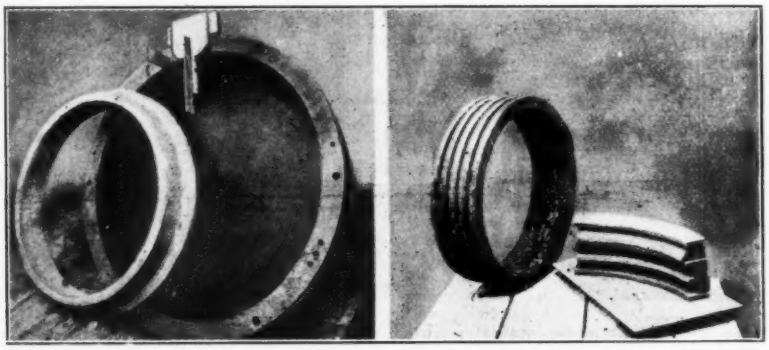

FIG. 7.—A POT-RING CASTING MADE BY SWEEPING UP A FORM IN A FLASK TO SAVE THE EXPENSE OF MAKING PATTERNS.

FIG. 8.—ONE OF THE ORIGINAL WAYS OF CASTING RINGS WHICH DID NOT PROVE ADVANTAGEOUS.

Piston rings from 8 to 29 inches in diameter have been made on the centrifugal machines. Two of these are installed. Rings up to 17 inches in diameter are cast in the smaller machine and the larger rings are cast in the other machine. The smaller machine, with a mould ready to cast is shown in Fig. 1. Moulds are carried to the centrifugal machine by a chain hoist operating on an I-beam. For different-sized rings different speeds of revolution are required, as it is endeavoured to revolve the flask at a speed which will produce a centrifugal pressure equal 100 lbs. per sq. in.

the inside of the flask is lined with cores, which are held down by a circular cast-iron ring as seen in Fig. 1. This ring is attached by bolts through the holes in the flanged rim, which is shown in Fig. 3. The cores are made in sections, five or six sections of a core being required to make a complete circle, depending upon the size of the ring to be cast. Six circular layers of cores form a complete mould for four rings. The cores are made of sharp sand, with an oil binder. A roll-over core machine, built by Henry E. Pridmore, Chicago, is used. At present

three cores are made at once in a wooden core-box, but later metal boxes will be provided and five cores will be turned out at a time.

A mould, partly made, is illustrated in Fig. 4, while one ready for the cast-iron cover ring is shown in Fig. 5.

The flask is screwed to the centre-pin of the centrifugal machine for casting. Metal is poured into the centre of the flask, after which the machine is started and the mould is revolved. The amount of iron to be placed in each mould is gauged close enough for practical operation by the quantity in a hand ladle used for pouring.

When the mould starts to revolve the molten iron is in the centre, as has already been stated. The machine is revolved at a speed to give a pressure equal to 100 lbs. per sq. in. The metal thus is forced into the mould through the only gates provided, which are in the lower tier of cores. The vertical runners are shown in Fig. 6.

The mould is spun for about 1½ minutes, by which time the metal has set. The flask is then removed from the machine and another put on. The mould usually is dumped at once and the flask returned to the moulding floor, after first having been cooled with water. In this way only enough flasks are needed to take care of one charge of iron in each of the two furnaces. New moulds are made each time while metal is melting in the furnace. Before the mould is dumped the circular cast-iron cover is unbolted and removed and a large proportion of the cores which have not been broken are recovered for use a second time.

A simple way of making a mould when it is inexpedient to make a core box is illustrated in Fig. 7. In this case only a few rings of a special size were desired. Instead of making a core box to produce cores for casting the rings separately, a lining of sand with a groove in it was swept with the crudely-made sweep shown in the illustration. Although this sweep is constructed in the most simple manner, it performs its function credibly. When the mould was made a top core was placed and a cast-iron plate was bolted to the top of the flask. The mould then was ready for casting. Extra machine work was required to cut the rings from this pot casting, and to turn off the extra metal which it was necessary to cast in the inside of the ring, in order to compensate for any variation in the amount of metal poured into the flask.

By the centrifugal method of moulding as now practised the casting is entirely surrounded by sand, which prevents irregular cooling and chilling. A mould made of cores which did not entirely surround the castings was tried in the earlier experiments. It was made as illustrated by the section of cores shown in Fig. 8. This also shows the appearance of the finished castings, bound together by the cylinder formed by the surplus metal necessary to ensure a sound casting. When moulds first were made with the cores entirely surrounding the metal in the castings, difficulty was encountered, due to shrinkage near the gates. This was overcome by increasing the size of the runners which now act as feed heads.

Briefly, the Wasson Company finds in this process that the moulds made in dry sand produce better rings, with all the benefits of dry-sand casting. The metal is cast under pressure and has a closer grain with greater strength. The loss due to dirty metal or other causes is small, as is also the percentage of metal in gates and riser. Much less sand is handled in making the mould.

The metal when cast in regular sand moulds has a tensile strength from 20,000 to 25,000 lbs. per sq. in., while metal cast in the centrifugal machine will stand a pull of from 30,000 to 34,000 lbs. per sq. in. Tests are made on test bars cast as already described. These bars are 9 × ¾ × 1⅛ inches, and are machined for testing to a section ½ × ¾-in. for a 2-in. length.

The loss from defective castings in the centrifugal casting method will average 2 per cent., which is much below the average loss obtained under the common method of casting piston rings. This loss may be accounted for partly by the fact that the heavier metal is thrown forcibly to the outside by the centrifugal pressure, and any slag or other dirt which may be present is held back in the risers. The success of the centrifugal method of casting piston rings has led the Wasson Company to contemplate the installation of an electric furnace for melting the metal, to provide greater melting capacity.

TWO NEW METHODS FOR MAKING BLAST-FURNACE FERRO-SILICON. — Two methods of making ferro-silicon are covered by patents (U.S. 1,318,763 and 1,318,764) granted to the estate of J. E. Johnson, jun., last October. In the first it is proposed to charge a high-temperature furnace with the usual ingredients for making ferro-silicon, with the exception that a feldspathic mineral is used as the source of silicon. At the high temperature needed to reduce the silica, the feldspar is decomposed and volatile alkaline metals driven off as oxides or carbonates, practically free from mineral acids, and easily purified into salts of much value chemically. The fuel on heat consumption of the furnace is not materially greater than when using quartzite in the mix. In the second patent it is claimed that low-carbon alloys can be made in ordinary furnaces, preferably a small blast furnace with enriched oxygen blast, if sufficient temperature is produced to reduce a considerable quantity of silicon from the charge. It appears that silicon has the important quality of excluding carbon from the alloys to a progressive extent as its quantity is increased. This undesirable silicon is then removed on tapping the alloy from the furnace by mixing with a molten reagent made of iron oxide, lime and a little fluorspar. Silicon then replaces the iron in the reagent and is fluxed as a lime silicate.

PROGRESS IN THERMO-ELECTRICITY. — The May lecture on "Recent Progress in Thermo-Electricity," delivered by Professor C. A. F. Benedicks, Ph.D., of Stockholm University, before the Institute of Metals, on Thursday evening, June 10, 1920, Engineer Vice-Admiral Sir George Goodwin, K.C.B., LL.D. (president), in the chair. Professor Benedicks first gave a short summary of his theoretical views upon the metallic conduction of electricity, which explained many matters not made clear by the former electron theory. A consequence of this new theory was that one has to conclude that even in a single homogeneous metal thermo-electric currents do occur; hitherto such currents were believed to be produced only when two different metals were present. Professor Benedicks gave a concise demonstration of the most important experimental evidence of the truth of this conclusion, utilising for this purpose various metals. In liquid mercury it had been possible for him definitely to prove the existence of thermo-electric currents, thus disproving the negative results of previous workers. A consequence of what the lecturer termed his "homogeneous thermo-electric effect" was that there must exist the reverse effect, the "homogeneous electro-thermic effect," including as a special case the well-known Thomson effect. The reality of this effect was duly made clear. A specially interesting demonstration was of a new rotating thermo-electric apparatus made entirely of copper and rotating in a magnetic field, the driving force originating solely from unequal heating (by means of a tiny gas jet) of thin strips of copper. The point at which the new knowledge brought forward by Professor Benedicks might have some practical interest lay in the possibility of reducing the thermal conductivity of metals by insulated sub-division into fine wires without impairing the electrical conductivity. The demonstrations were carried out with the aid of a galvanometer kindly provided by the Cambridge & Paul Instrument Company.

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Institution of British Foundrymen.

BIRMINGHAM BRANCH.

Annual Meeting.

At a meeting of the Birmingham Branch on April 8 (Mr. H. L. Reason in the chair), the business of the annual meeting of the Branch was first transacted.

Mr. F. Holberry was elected Branch-President for the forthcoming session. Mr. C. B. Roe was elected Senior Vice-President and Mr. H. Field (late Branch Secretary) Junior Vice-President. Mr. F. C. Holberry was elected Hon. Secretary of the Branch, and the following gentlemen as members of the Branch Council:—Messrs. W. J. Flavell, H. Winterton, C. B. Pugh, T. Vickers, F. C. A. H. Lantberry, F. Johnson, J. R. Johnson (West Bromwich), A. Wardle, E. H. Tyson. Mr. F. B. Holberry was appointed Branch Delegate to the General Council, and Messrs. T. Vickers and C. B. Roe auditors to the Branch.

The Secretary's report on the past session stated:—

Seven lectures have been held, and the Papers have been of a practical nature on foundry subjects and have attracted some discussion. The Council feel, however, that added interest would be given to our lectures if more members would take part in the discussions, thus giving others the benefit of their views and experience and using the Institution as a means not only of helping themselves, but of helping others also. In addition to these meetings two visits have been arranged, that to Messrs. the Austin Motor Company, Limited, being largely attended and highly successful, and joint meetings held with the Birmingham Metallurgical Society at Coventry, and the Wolverhampton and District Engineering Society at Wolverhampton. Regarding the membership the session closed with an advance of 11 on last session, the total being 194.

THE BRANCH-PRESIDENT proposed a very hearty vote of thanks to Mr. Field for his work as Hon. Secretary during the past year. The proposition was carried with acclamation.

Permanent Moulds and Centrifugal Castings.

MR. J. E. HURST then gave the Paper which he had read at the Annual Conference in Liverpool in July, 1919. (See *The Foundry Trade Journal*, August, 1919.)

Discussion.

In the ensuing discussion Mr. Reason said the information given in the Paper with regard to the correct analysis of material for such moulds was very valuable. Permanent moulds were very largely used for intricate castings for textile machinery, but there were many instances in which it required a good deal of thought to decide whether the use of permanent moulds was a commercial proposition. The question was, whether the greater output could be obtained from permanent moulds or from moulding machines. He thought that the moulding machine with a number of patterns enabled them to get a much greater output than where they had to wait for the metal before they could commence casting. That, he thought, gave machine moulding in regard to output a very long lead, but when it came to the question of the physical properties of the casting, there was no doubt that vastly better results were obtained from practically the same analysis by using permanent moulds. As to casting by the vacuum method, it was evident that there were possible developments in connection with the production of castings in this way.

MR. F. HOLBERRY was very much interested in Mr. Hurst's remarks on growth and distortion. In casting chilled rolls they had a great deal of experience of this trouble, and he would be very glad if Mr. Hurst could tell them how they could get over the trouble of distortion and cracking. With regard to high phosphorus, he had always been under the impression that high phosphorus for die or chilled castings was fatal, and they always aimed at getting very low phosphorus. In casting chills for making very heavy chilled rolls they very nearly always found in pouring they got a good deal of porosity, due, he supposed, to the long range of cooling and the character of the metal. One portion of the paper, he thought, might be very useful, namely, that which referred to Mr. Hurst's method of casting permanent moulds in chills. He himself, in casting chills, did not use a sand core or loam core, but used as cores cast-iron bricks. These gave them a much closer and better interior, and they found in using chills so cast that they did not suffer any loss through the chills giving way. They also found a great advantage in annealing the chill before using it.

MR. F. JOHNSON said that among the points which had occured to him while listening to Mr. Hurst's Paper, one was the possibility of applying the centrifugal method to the production of what were known as tube ingots for tube-drawing in brass or other copper alloys. The usual method was to cast these tube ingots around a sand core and inside an outer cast-iron mould. A section of such a tube when cast showed that the outer portion was sound, whilst the inner portion which had been in contact with the sand core was porous. It had often struck him that an improved method was necessary to produce a sound tube ingot. He did not know whether Mr. Hurst had thought of all the numerous difficulties which had to be faced, but it seemed to the speaker there was a possibility of applying the centrifugal method to castings of that description. At present, to comply with the Admiralty specifications, these tube ingots had to be specially bored so as to remove the roughness from the inside. Another point that had occurred to him was the possibility of making permanent moulds in malleable cast iron. He would be glad to have Mr. Hurst's opinion on that suggestion. It seemed to him that malleable cast iron would be free from some of the inherent difficulties which were found in cast iron used for permanent moulds. Malleable iron should be less susceptible to the erosive action of the molten metal and better for resisting external and internal stresses. Another point in connection with casting in permanent moulds was the influence on the properties of the metal or alloy thus produced. Two instances had come to his notice recently. One was that of Admiralty gun-metal cast in an iron mould. The part of the casting adjoining the mould itself was very different in properties from the metal that was further away from it. The outer skin of metal was very much freer from the brittle constituent (eutectoid) and, strangely enough, it was also lower in copper content. The

composition was such as would normally give a structure with an excess of the brittle constituent, while, when cast in a chill, the structure of the outer skin was that of an alloy of higher copper content. Nearer the centre of the casting, the brittle constituent was in such excess that the properties of the metal from the mechanical point of view were far inferior to those of the metal at the surface of the casting. The other instance was that of some brass tube casting which, when cast in chill moulds, gave a material in the outer section richer in zinc than was the material at the centre. Probably other points with regard to the influence of permanent moulds on the structure and properties of the metal in the castings would occur to members. These matters had to be taken into consideration, because, although one might produce improved castings with some alloy in permanent moulds, it did not follow that one would always be able to obtain them in other alloys.

Mr. H. Field asked if the centrifugally-made castings came out of the moulds in a machinable state, or whether they needed to be annealed before machining. He realised that a thick casting would be quite grey and soft, but in the case of a thin cylinder, say of from ½ in. to ¼ in. section, it seemed that even if there was a high percentage of silicon the casting would be chilled and would not be suitable for tooling direct. In his experience, any casting made in a permanent mould, when the section was not more than ¼ in. to ½ in. the metal was chilled or possibly white right through. He had also found that the metal was very much inproved by annealing after casting. Mr. Hurst had mentioned a tensile strength of 18 tons, but he (Mr. Field) had seen castings with a tensile strength of 20 to 22 tons made in permanent moulds and annealed. He would like to ask whether the centrifugal casting machines were kept in continual use or whether any cooling process or interval for cooling was necessary, as the chill on the castings would be more or less influenced by such conditions.

Mr. W. J. Flavell remarked that Mr. Hurst had mentioned the year 1850 as the date at which permanent moulds were first used. He (Mr. Flavell) would point out that in casting chilled rolls they were used many years before that date. He believed die casting would play a very much larger part in the foundry trade of this and other countries than it had done in the past. He had remarked on a previous occasion upon the small amount of attention which had been given to the possibility of improvement of big cast chilled rolls. At present they were using in the casting of chilled rolls the same methods as were used thirty years ago. He thought the annealing of the chills before using, as practised by Mr. Holberry, was a very good idea. One of the best men he ever knew in the trade used to have the rolls annealed after casting, but they never found that a roll so treated gained much in length of life. In the steel foundry they had men trained to know what results they were going to get in melting; if a roll of ten tons weight was a bad one it was a serious matter, and, therefore, they had to avoid the risk of failure by having their men properly trained. They wanted the same kind of training for the men in the iron foundry.

Mr. Hurst, replying, referred to the remarks of Mr. Reason with regard to the roughness of the interior of centrifugal castings, and said he would like to correct Mr. Reason on that point, The actual finished castings when separated from the machine were not rough; they were actually very smooth. There was roughness only if the slag and sulphur segregation were allowed to remain, but by the flushing out process, the addition of molten metal over and above what is required to fill up the mould, these segregations were swept away and the casting came out with a surface comparatively smooth and much superior to the surface obtained by casting in a dry-sand mould. With regard to the phosphorus contents of chills, he quite agreed with Mr. Holberry that it was advisable to have a low phosphorus, particularly in chills for heavy rolls. But with regard to very smalls chills they have not found that phosphorus had any considerable influence. The composition he had given was not recommended except for comparatively small work in which the conditions were not at all to be compared with those of casting heavy chilled rolls. He should explain that they never ran these mould castings at a temperature exceeding 650 deg. C. It might be that in moulds for making chilled rolls, of which he had had no practical experience, the temperature of the metal mould was considerably in excess of that. As the temperature of the metal centrifugal moulds never exceeded 650 deg. C. it would be seen that there was no danger of the phosphorus melting. At the same time he could quite conceive that even in their small moulds a very low phosphorus might be an advantage. The use of malleable cast-iron for moulds as recommended by Mr. Johnson would be an advantage, provided they could obtain a reliable malleable cast-iron. The great disadvantage of malleable cast-iron was the difficulty of ensuring uniformity of constitution. If they could get over this difficulty malleable cast-iron might answer the purpose and the extra cost would be set off by the increased length of life. At the same time there was a probability that some of the extremely soft malleable cast-irons would behave like steel, and they had found that steel did not give satisfactory results. With regard to Mr. Holberry's remarks on the annealing of moulds for the production of chilled rolls, he thought it probable that this would increase the life of the moulds. They did not think it necessary to anneal their small moulds, but it was the practice to anneal moulds which were to be used for castings of a complicated design. As to the possible use of centrifugal casting for brass and copper tube ingots, as suggested by Mr. Johnson, several patents have been taken out for the production of copper rolls for printing machines by this method, and he believed that there was a firm still casting copper rolls centrifugally. They had had very little experience with regard to the soundness or otherwise of brass or copper tubes cast centrifugally. They had made some experimental castings in gun-metal centrifugally and had found the same phenomena as Mr. Johnson had mentioned with regard to difference of composition between the exterior and the interior. There was some trace of a similar effect in cast-iron. Different types of crystallisation were met with in different sections, and this was probably accompanied by a difference in the physical properties of the outside from those of the inside. But his experience with the non-ferrous metals so far was so small that he would

not care to give any definite opinion as to the behaviour of gun-metal or yellow metal in centrifugal casting. In reply to Mr. Field's question the castings could be machined immediately after they had come from the casting machine and cooled down. They could be machined at the minimum rate of 45 ft. per minute. The castings had a silicon content not exceeding 2.78 per cent. Each casting came quite freely out of the barrel. A slight chill was found at the corner of the flange, but as this part was not required for piston ring pots, it was of little significance. The centrifugal casting machines could be kept in continuous use. The first castings, of course, were perfectly chilled, but when the mould reached a certain temperature one began to get castings which were free from chill. Their experiments had not yet reached such a stage at to justify them in making dogmatic statements as to all points in relation to centrifugal casting. He would be pleased to give any member any information that might be desired.

SHEFFIELD BRANCH.

Election of Officers.

A Sheffield and District Branch was held on Friday, April 16, the President (Dr. W. H. Hatfield) in the chair.

The election of officers for the ensuing year resulted as follows:—President, Mr. J. R. Hyde; Senior Vice-President, Mr. John Watson; Junior Vice-President, Mr. W. J. Dawson; Members of Branch Council, Commander Jackson, Messrs. W. Oxley, W. F. Bagnall, and W. A. Walker, in addition to Messrs. F. Darley, T. Brown, C. Webster, F. Atkinson, and J. A. E. Wells, who remain in office. Auditors (*ex-officio* members of Branch Council), Captain Rundle and Captain Ambrose Firth; Hon. Sec. and Treasurer, Mr. Macdonald, of the Brightside Foundry (succeeding Mr. A. Whiteley, who retired owing to pressure of other work); representatives on the General Council of the Institution, the President, Secretary and Senior Vice-President.

Dr. Hatfield said the Branch was in a very satisfactory position. A year ago the membership was 170, while to-day is was 195, an increase of 25 on the year.

Discussion of Foundry Matters.

A general discussion on foundry matters then took place. Members were invited to raise questions on which they desired the opinion of others.

Mr. Shaw said he should like to ask Dr. Hatfield's opinion as to the influence of iron oxide in cast iron. He was no doubt quite in touch with the statements of the American blast-furnacemen who said that the presence of oxygen strengthened the iron. That might or might not be, but he wished to know if it was in any way beneficial to castings. In comparatively low-silicon irons—below 2 per cent.—they got a great deal of iron from the blast furnace that did contain an appreciable amount of oxide, and this was either detrimental or otherwise. He thought it was a point that deserved rather serious consideration by people who were using comparatively low silicon irons.

Dr. Hatfield said pure iron, containing no other element, would, he thought, dissolve oxygen in the liquid state. That seemed to be thoroughly established by a number of researches and also by many lines of reasoning. The main support of that statement was the fact that if they added silicon and manganese, or aluminium, to relatively pure iron, under certain conditions, they did in the finished product find oxide of silicon, oxide of manganese, and oxide of aluminium; and therefore it was fair to assume that the oxygen was present in solution in the iron. That was the mechanism of the production of what they called non-metallic inclusions in steel. Any cast iron which contained more than 0.3 per cent. of silicon would, when cast, be solid (*i.e.*, it would be free from blow-holes), and it was his opinion that if there was more than 0.3 per cent. of silicon in the iron, that iron was free from oxygen. A liquid iron containing say 1.3 per cent. of silicon, 1 per cent. of phosphorus, and 0.6 per cent. of manganese, was one which, according to the suggestions of the Americans whom Mr. Shaw was quoting, might contain oxygen. But he (the speaker) said quite definitely that could not contain oxygen, because the silicon, the phosphorus and the manganese had a much greater affinity for oxygen than the iron in which they were dissolved, and the result was that, before the oxygen could form oxide of iron and so be dissolved in the iron, it would form oxides of those metals, which would come to the surface, and so be eliminated from the iron, by specific gravity alone. He was satisfied, therefore, that in a good foundry iron of any description, whilst the silicon and the manganese were there, oxygen was absent. If oxygen were present, it would have to be in the iron, and whilst those more readily oxidised elements were present they protected the iron.

Mr. Shaw, explaining his point further, said that sometimes, when a blast furnace was making forge iron, temperature causes would result in the production of an iron which was too grey for forge purposes, and which was turned over to the foundry side. Invariably, after it was melted, that iron was in such a condition that any ordinary moulder could tell that it was a forge iron. These irons had a certain amount of strength, but they lacked fluidity entirely. They gave a seam along the top of a round hollow casting, and it would not run—it lacked life. Also, when the metal was melted in the ladle they got a series of little black spots the size of a shilling. These were not air bubbles, and did not protect the surface. They could be taken off, and were identical with mill scale in chemical composition. The addition of 0.8 per cent. of manganese to that iron would stop all this at once. He should like to know the explanation.

Dr. Hatfield said he was inclined a little to disagree as to the facts. It was simply that they took a forge iron which would give a grey iron and therefore was handed over to the foundry. Whether an iron was grey or white was not necessarily due to composition. When they got to the forge iron end of the scale of pig-irons, they found that they had got among the low-silicon irons, and when they got to a certain percentage of iron it was touch and go as to whether they would get a white or a grey iron. The casting temperature—the temperature at which the iron ran out of the bath on to the pig bed—would, at a certain critical position, determine whether that iron was to be grey or white. At any rate, there was not much difference in composition between the white forge iron and the grey forge iron. In

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any case they were low in silicon. If that iron were melted in the cupola—or certainly if melted in the air furnace—they found that the air blast could more easily get at the carbon contained in the iron, and reduce the carbon, because there was not sufficient silicon and manganese to take the oxygen of the blast and so protect the carbon. They got a lower carbon content than they did in the ordinary foundry iron. In ordinary foundry irons the silicon content and the manganese content, owing to their affinity for oxygen, protected the carbon from oxidation. He submitted, therefore, that one reason why they got what was apparently a sluggish iron was that, owing to the low percentage of silicon, the carbon had been oxidised, and so reduced to a greater extent than the ordinary foundry irons. Now as they lowered the carbon content in cast iron the freezing temperature went up. Whereas iron containing 4.3 per cent.—that was the eutectic composition of the iron—melted at 1137 deg. C., if they got their carbon down to 3 per cent., or 3.2. which was quite a common percentage, the freezing temperature went to something like 1,250 or 1,280; and therefore, it would be seen, such iron, which had the same initial temperature in the ladle, would freeze much more rapidly than the ordinary foundry iron made in the ordinary way. Therefore he submitted that the sluggishness and the general properties could be explained on purely chemical grounds rather than by the presence of oxide of iron in solution in the iron.

Mr. Shaw said this did not quite meet the case. They got the metal in the ladle, and did not decrease the carbon by the addition of ferro-manganese, or increase it to any appreciable extent. If they ran ferro-manganese down the spout into that very ladle, they got a fluid iron at once. They had the same carbon, and the same everything, and the addition of manganese was practically nil.

Dr. Hatfield said he would reply that they did not get a more fluid iron. As Mr. Shaw knew, these irons were high in sulphur.

Mr. Shaw: Yes, always 0.12.

Dr. Hatfield: And the manganese is often very low.

Mr. Shaw: No, 0.7.

Dr. Hatfield: Oh, very often they are very low indeed.

Mr. Shaw: You always control your manganese.

Dr. Hatfield maintained that many of these irons—those from the Bessemer blast furnace for example—were very low in manganese. One possible explanation was that with the high sulphur, and not sufficient manganese to neutralise that sulphur, they had an effect which was recognised in the foundry. When they added the manganese they combined with that sulphur forming manganese sulphide, and it was quite possible that the globules that Mr. Shaw referred to were sulphide of manganese. When that sulphide of manganese came to the top, it would burn. But he felt quite satisfied that a foundry iron of that description was not the metal that was used for making the ordinary run of foundry castings; it should be judiciously mixed with other irons, in which case he thought the difficulty would disappear.

Mr. John Watson said that about ten years ago he had a difficulty with manganese steel, and, although he overcame it, he had never had the matter properly explained. At that time his firm were in trouble with regard to manganese-steel castings, which were cracking. Some of them cracked in about a week, and others would crack if one sat on them. He went into the matter, and found that the method of making manganese steel was as follows:—the pure manganese was melted in crucible pots; then a ladle was put in on the scales, a certain quantity of the melted ferro-manganese turned in, and the ordinary Siemens ladle brought over the top of it, and as much charge of probably 20 per cent. carbon steel as would make up the weight necessary to produce a 12.5 per cent. manganese steel was run, and that was poured into the moulds. He changed that procedure. After running the steel in he teemed the original ladle into another ladle so as to get the mixture better—thus they had three ladles. They continued to have some difficulty, and complaints as to the castings breaking. One day, all the castings in the charge were good. He did not allow any more to be made until he had found out what the difference was. He had an analysis made, and found that it was the silicon content that had altered. He went straight to the man who melted the ferro-manganese, and found that, instead of melting all ferro-manganese, he had mixed some ferro-silicon, so that they got 0.8 per cent. of silicon in the manganese instead of 0.2 per cent. as they had before. After that, he got the chemist to make up a charge so that they could get 12.5 per cent. of manganese and 0.8 per cent. of silicon. He believed that was still the working percentage to-day, and they had never had trouble since. He had never been able to find out why the increased silicon should have this effect, although he had his idea. In the micrographs of the 0.2 silicon melted the junctions of all the crystals showed just like little lakes. In the 0.8 silicon there was no sign of that at all. His own impression was that the carbon, in the 0.2 silicon, had been in a different condition.

Dr. Hatfield asked if the carbon content of the steel which cracked was the same as that of the steel which did not crack?

Mr. Watson said it was—about 1.3 or 1.42. The only difference was that the silicon was raised from 0.2 to 0.8.

Dr. Hatfield said the best that any scientific man could do, really, was to accurately observe facts. They could, for instance, discover gravitation, and observe all the facts concerning gravitation. As to why it acted was a problem that they had not yet discovered, but still they made the law very useful. He was afraid they would have to put Mr. Watson's case, for the time, in the same category. They thanked him for the facts, but he was afraid they must leave the explanation to a future date.

Mr. W. A. Walker raised the next question, which was:—Suppose one had some alloy steel electric castings, what means should be adopted to make them machineable?

Dr. Hatfield, in reply, said it might be done in two ways. The fact was that if the steel was hard, it was because it had not attained equilibrium, but was in a metastable state. That steel, when at very high temperatures, above the critical point, say, existed as a solid solution, and air cooling would produce a very hard condition. It did not need to be quenched quickly for that condition to arise, as the elements present had rendered the carbon change very sluggish, so that

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ordinary air cooling was sufficient. Were the steel cooled very slowly from a very high temperature—above its upper critical point—it would be soft. He went on to give the explanation of this. The cooling curve of carbon steel, showed a critical point at about 700. If they added the other elements to the extent referred to in this case, and air-cooled the metal, they would find that the critical point was not present, except to a very slight extent at the bottom of the curve. The more slowly they cooled the steel, the higher would the critical point be. It was a physico-chemical change that they had to control by speed of cooling. If they only cooled sufficiently slowly—he would not say how slowly off-hand, but very slowly—from their hardening temperature, they obtained the steel soft. But it needed to be cooled very slowly—away from draughts, and that sort of thing. Another way of obtaining the condition which Mr. Walker wanted was by tempering, which was softening. It was only necessary to temper the steel sufficiently to get it machineable. If Mr. Walker was having difficulty in softening a steel of that kind, he (the speaker) advised him to take a heating curve, to heat the steel to 20 or 30 degrees under the critical point, maintain it there for some time and then cool it down, and it would be quite soft for machining.

Mr. Walker said they started on the pit sample, which was about 10 in. long. They heated it to 900, and cooled it in ashes, and nothing happened. They did the same thing again, leaving it longer in the furnace, cooling it in ashes, and it was no softer. They wanted drillings from it, for analysis, but it could not be drilled. Then they reheated it up to 650, and quenched it in oil, but nothing happened. They reheated it again to 700, and quenched in oil, and again nothing happened. Then they reheated it to 900, and cooled it in kieselguhr, and nothing happened. They repeated that process, and altogether they heated the steel eight times. During the last cooling it cracked. They found then that it was soft enough to drill, but not particularly soft. Its softness was only for a distance of about ½ in. in. They had not done the castings yet.

Dr. Hatfield: This treatment only needs to be applied once. It does not matter what steel you have, if you take the heating and cooling curve, you can devise a treatment that will soften it.

Mr. Walker: How long ought it to be soaked at high temperature?

Dr. Hatfield: It depends entirely on the mass of the steel and also on its composition. Generally, if you can rely on its being soaked through, and give it a few hours for luck, you are all right.

The meeting concluded with a hearty vote of thanks to the President and Secretary for their services during the past session.

COVENTRY BRANCH.

Malleable Castings from the User's Point of View.

At a meeting of the Coventry Branch of the Institution on March 26, a paper was read by Mr. F. C. A. H. Lantsberry, M.Sc., F.I.C., entitled "Malleable Castings from the User's Point of View." Mr. Andrew Harley (the President of the Branch) occupied the Chair.

The art of making malleable castings was due to the genius of the French savant Reaumur, who early in the 18th century made the discovery that the effect of heating hard iron castings in oxide of iron was to soften them perfectly. The process was introduced into Great Britain in 1804.

As showing the importance of the industry, a million tons of malleable castings were made in the United States every year, and any improvement in the process was certain to widen its scope of utility. Good malleable could be regarded as intermediate between ordinary cast iron and mild steel, possessing in a sense the virtues of both. Grey cast iron could, of course, be cast into very intricate shapes, but, although capable of withstanding high compressive stresses, it was weak in tention, and had practically no shock resistance It was therefore inadmissible as material for use in many parts of modern machinery. Mild steel, on the other hand, had a relatively high tensile strength and resisted shock successfully. But the only adequate method of producing intricate shapes was by the laborious and expensive processes to drop forging and machining. For many purposes, therefore, the use of the steel was ruled out on the score of cost. During the last few years, however, considerable advances have been made in the production of steel castings, and there was every indication that in the near future small steel castings would become very serious competitors of malleable material. On account of its comparatively low melting point, however, white cast iron lent itself to the production of intricate castings of thin section, and these castings after proper malleableising were a great boon to the engineer designer.

Design was usually carried out with the dual object of producing effect and rendering machining operations as easy as possible. While these factors were important they were not the only ones. In the design of components in malleable produced by the European process uniformity in section was essential.

From the user's point of view the second essential in a malleable casting was that it should be machined fairly readily. Machinability and malleability ought to be almost synonomous terms, yet one of the greatest difficulties arose in connection with machining and might arise both from under and over-annealing. Under-annealed castings might be recovered by re-annealing, but such castings returned for re-annealing were as likely as not to come back over-annealed. Under-annealed castings were a continual source of annoyance to the user, very largely because of the enormous number of breakages of tools which took place.

The speaker proceeded to describe the British and American processes. The European or "white-heart" process was contrasted with the American or "black-heart." The two processes were alike, however, to the extent that the control of both depended upon knowledge of the relationship existing between the carbon and the iron and how those relationships were affected by external conditions, such as the presence of other elements, and the thermal treatment to which the alloys have been subjected.

A series of diagrams were exhibited showing the constitution of iron carbon alloys and illustrating the experience of carbon in two forms, graphite and cementite; and next the speaker showed the important part played in malleable work by silicon, as the mixing of the charge was based on the silicon content. The influence of the

silicon was important in that its presence determined the nature of the material which crystallised initially from the molten metal. In addition to altering the composition of the eutectic, the silicon materially influenced the stability of the cementite, promoting the formation of graphite.

Sulphur also played a very important part in malleableising. With regard to sulphur, in American practice it was customary to use low sulphurs, below 0.07 per cent, whereas in European processes high sulphurs were used up to 0.4 per cent. The importance of high sulphur, consisted in its power to increase the stability of the carbide, and its influence increased proportionately as the silicon content decreased. Levy assumed that the first stage in malleableising was the balling up of cementite which was prevented by the presence of sulphide films. Dr. Hatfield, however, held that as the sulphur was increased so was the tendency to associate with the carbide. There were indications that as the temperature increased the sulphur was likely to go into solution. The researches of Treitschke and Tammann indicated that above 800 deg. C. iron was capable of holding about 1.5 per cent. silicon in solution. Manganese sulphide did not possess this solubility and consequently the addition of manganese reduced the action. The effect of sulphur could be largely controlled by adjusting the silicon and manganese contents.

In European malleable, said the speaker, the phosphorus content was low, but it was higher in American black-heart. The phosphorus in grey iron increased the fluidity, giving better castings. It was important to know how much could be added with safety to malleable material. Dr. Hatfield's investigation proved that no serious effects resulted up to 0.25. In the specimens he employed the carbon was 2.8 to 2.9, the silicon 2.75, the manganese 0.25 and the sulphur 0.04. The effects of tht addition of phosphorus are shown in the following table:—

Per cent.	Strength.	Per cent.	Strength.
0.05	16.4	0.287	11.21
0.10	14.4	0.6	14.72
0.145	17.6	0.83	13.27
0.23	16.51		

Some tests made at Birmingham University led to similar conclusions. Phosphorus apparently had no effect on the annealing process.

The author proceeded to give a range of compositions which in his experience before the war yielded successful castings, as follow:—Combined Carbon, 2.8 to 3.1; Graphite, 0.04 to 0.23; Silicon, 0.45 to 1.5; Sulphur, 0.09 to 0.54; Manganese, up to 0.5. Since the conclusion of the war he had made other analyses as follows:—Combined Carbon, 2.11; Graphite, 0.06; Silicon, 1.19; Sulphur, 0.104; Phosphorus, 0.06 Manganese, 0.04. In melting, the mixture should be calculated on the basis of the silicon content, which should depend on the size of the casting, and the sulphur and manganese contents of the material available.

Discussion.

The PRESIDENT said he believed that the time was not very far distant when those difficulties of producing sufficiently thin steel castings would be overcome, and then he thought they might bid good-bye to malleable castings, which were really very treacherous for engineering purposes. It was quite true that cast steel was sometimes equally treacherous, but there was no comparison between the physical qualities of a good steel casting and a good malleable casting. Everyone must agree that the difficulties of a malleable founder were real and genuine, although for many of them he had nobody to blame but himself. It was almost amusing, although in a way it was pitiful, to think of the small malleable founders trying to make a good malleable casting without knowing very much either of the materials they were using or of the scientific principles underlying the process of annealing. While it was quite true that annealing was very important, a very large proportion of the difficulties experienced in annealing were due to defects happening at a prior stage. Very often a founder tried to get good results out of a big ovenful of stuff. Very often in that oven they had a great variety of castings and he would defy anybody to get uniformity under such conditions. The silicon content varied very greatly and that would suffice to prevent uniformity. He had had some hard experiences in connection with malleable castings. Obviously, it was quite impossible to get good malleable with many of the analyses which had been exhibited. A percentage of 1.11 silicon was ridiculous. Then with regard to sulphur, wide variations were obviously bad and they could not get uniform results. But he knew from experience that first-class malleable castings could be produced with a sulphur content up to 0.45 per cent. He rather agreed with those people who considered a rather high sulphur better than a low one. Personally he preferred about 0.35 of sulphur, though the phosphorus ought to the low. He thought up to 0.2 per cent. it did no great harm. Phosphorus, however, was rather a dangerous element. Manganese had an importance of its own and, like other constituents, should be regular. To sum it all up he thought that the best malleable came from castings in which the carbon was held most securely. Undoubtedly a high silicon which rendered the cementite unstable was bad. On the other hand, the proportion which held the cementite stable seemed to be good. If they had an iron containing 0.35 silicon and a similar proportion of sulphur, provided they had proper annealing at a proper temperature and for the correct time, they should get the best malleable. It was impossible to cut down the time. Possibly a low sulphur did not make the highest class of malleable

Many of the difficulties connected with annealing were caused by irregularities at a prior stage. While grey iron founders, and possibly even brass founders, could scrape along without a chemist or a laboratory, it was absolutely impossible for the malleable people to do so. It was absolutely essential that they should know the composition of the pig-iron, also how to melt the iron, and he thought he had proved some years ago that iron should be melted in a crucible for the malleable trade. But if they melted in a cupola greater precautions must be taken to produce a uniform product in the hard condition. Those precautions were quite simple, but they required analysis by a chemist. They could not always get to know all that was necessary merely by fracture, and they wanted to keep an eye on the silicon percentage. If they regulated their scrap according to the percentage of silicon they ought to get a uniform molten product from the cupola. In order to know the composition, the malleable founder ought to have a laboratory, and if he could not afford one he

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should combine with somebody else and several small firms might run a laboratory between them. With regard to the variation of temperature in the annealing furnace, if the annealer had to put a great variety of stuff through one oven—fairly heavy, medium and light castings—it was obviously necessary to give these varied castings different temperatures if they were to be satisfactory. To do that properly the founder ought to know approximately where the variations occurred in the composition of the different parts, and if he knew his job he put the lightest castings of sections in the coolest part of the oven and therefore stood a chance of getting all the varieties decently annealed. That, however, was a system which ought not to exist. The oven should be at a uniform temperature for certain castings which should be classified accordingly and annealed in batches.

With regard to the recombination of carbon and iron, he could assure Mr. Lantsberry that was an absolute fact. On one occasion he was using iron with about 0.75 silicon similar to two of the analyses shown there. Those particular castings had to be brazed and they got the very highest temperature possible, approaching 1,100 deg. They became hard and brittle when being brazed. They were simply heated to a high temperature. and the castings became different things altogether, becoming weak and brittle and the fracture entirely different—in fact they were quite unrecognisable. There undoubtedly the carbon came back into combination and spoilt the qualities of the castings. Those castings had to be brazed and the cure for that condition was a low silicon of 0.35, making them hard before annealing. Castings in that condition were able to stand the brazing treatment without any danger. With higher silicon they were spoilt as soon as they came in contact with the brazing flame. He thought that information would be of considerable value to those who had to deal with cycle and motor-cycle lugs.

Mr. Hurren said the malleable industry had made very little progress up to the present. Many of the methods in use were practically the same as those introduced by the originator of the process in 1722. The crucible method had been credited by Mr. Lantsberry with giving the best results. No doubt that was true if ordinary control was exercised, though probably, the comparatively better results were due to the fact that firms dealing almost entirely with the crucible method usually had a much smaller output than those employing the cupola method. With increased output, they were bound to have an increase of troubles. He did not agree with the President that a silicon proportion of 0.35 was just about right. Mr. Harley had, however, qualified his statement afterwards by suggesting that he had cycle and motor lugs in view. Probably if he tried 0.35 silicon on motor parts, having a section of 3-8 in. or over, he would find that the annealing went inwards 1-32nd of an inch, and below that there was practically white iron. His (the speaker's) experience suggested that 0.5 silicon would be about right for cycle lugs.

Mr. E. H. Broughall said he was obliged to use malleable castings of a rather difficult type to make and got a lot of trouble with them. Mr. Harley had expressed his preference for steel castings, but (Mr. Broughall) had found more trouble with them than even with malleable. Great stress had been laid by the author and the president on the value of scientific work in connection with the industry. He had his doubts on that point and was wondering whether malleable manufacture had become a lost art. He doubted whether they had the same class of man producing "malleable" as they had thirty years ago. The President almost went so far as to say that they could not produce "malleable" unless they had a laboratory. Yet the finest malleable castings ever produced were turned out by a founder of a past generation, who probably did not know what laboratory was. Malleable castings were obtained then which could not be got to-day.

Mr. Roberts said most people would admit that during the past years it had not been so easy to get the irons that were used a few years ago. It was now impossible to get the finest iron or the best coke. While he was in perfect accord with what had been said about the desirability of having a laboratory, it must be remembered that the bulk of the malleable iron casting business in the country was done in small establishments, and it would not be contested that establishments could not afford more than a limited overhead charge in proportion to their output; and therefore while the larger establishments might afford to give such assistance to their foundries, the smaller ones could hardly be expected to do so. Nevertheless, it was somewhat curious that some of the smallest firms turned out castings equal in quality to the largest.

Mr. Hill remarked that with regard to kish he never remembered seeing a condition of kish raised in the ladle, and he believed that condition was limited to cases where hematite and especially Welsh hematite had been used.

Mr. Lantsberry. replying on the discussion, said that as to sulphur, in some cases he had used up to 0.55 per cent. and still managed to make good castings though it had not previously struck him that sulphur might assist in getting a really good malleable casting; he now thought Mr. Harley was quite right in his contention. He (the speaker) had shown a photograph of a bad casting produced from a white iron low in sulphur. They were now fairly clear that temper carbon was not removed as such, and where it had been produced it must go back into solution prior to removal. That being so, they could see how the sulphur could assist in the carbon removal, because by stabilising cementite in the earlier part of the operation, the long process of getting into solution the carbon previously thrown out was prevented. In that way it was quite possible that the sulphur would be of considerable assistance. As to annealing difficulties with different types of furnaces, he (the speaker) had repeatedly seen castings requiring high temperature put into exactly the same place with castings requiring minimum annealing temperature and he had also had castings to deal with which had obviously never been near the proper annealing temperature. In those conditions the variations of temperature were dangerous and prevented good work. The possibility of getting a uniform temperaure was a *sine qua non* in annealing furnace. It was quite easy to arrange to get a non-uniform temperature in such a furnace. They had only to stop up the part admitting the heat or obstruct the waste outlet. It was not difficult to produce the temperature gradient which they undoubtedly required for annealing castings of different classes. But the important part to be secured was that every portion of the furnace in which annealing was being carried on must be at least up to the temperature at which annealing could take place.

As to the castings which Mr. Harley had described as becoming brittle after brazing, he (the speaker) had particularly referred to malleable castings for cycle brackets, and it was clear that for such work the malleable founder must not merely reduce the carbon to temper carbon, he must remove it. Material which contained carbon, say up to 0.24 in the combined state, was best for the user of small malleable castings. But if the casting contained more than that percentage it usually contained graphite, and it was possible during the process of brazing for the temper carbon to go back into solution and produce a material which was really quite a hard steel. He had, in fact, seen brazed lugs break like glass when dropped on the floor.

He was ready to admit that it was possible to produce as good castings from the cupola as from the crucible. But it was an infinitely more difficult matter. It was possible to get increased ouput, but unless they adapted the copula to that class of work they often failed to produce castings which could be called malleable in the true sense of the term.

He had been asked to give an opinion as to whether 0.5 or 0.35 per cent. of silicon was the correct proportion. There was no serious difference between the two proportions and probably the user would be quite happy with either, and the conditions would not vary greatly. He was inclined to agree with Mr. Broughall that they had not the kind of men they had casting malleable thirty years ago. He was absolutely certain those men took greater interest in their work, and that interest was a very important factor in malleable production. He was disposed to attribute the formation of kish to the decomposition of cementite, a theory first put forward by the American metallurgist, Howe, Another point which seemed to confirm that was that kish never obtained in low-carbon irons and the cementite needles were not formed from the liquid. The cementite was formed after solidification.

LANCASHIRE BRANCH.

Oil-Sand Cores.

At the meeting of the Lancashire Branch of the Institute held on May 1st at Manchester, Mr. J. Masters gave an address on "Oil-Sand Cores." He said he did not claim to be drawing attention to a new practice in iron foundries. Many members no doubt remembered the days when various kinds of liquids and other materials were used in conjunction with sand in the making of cores—beer, resin, treacle, flour, gums, linseed meal, boiled linseed. In many cases good results were obtained, but a long time was required for the preparation of the materials and they were rather expensive. During the war, methods giving maximum production were adopted, sometimes regardless of cost, and the experience gained could now be applied in general foundry practice.

There were many kinds of oils used, and the proportion used varied according to the quality of the oil itself and the nature of the casting for which the core was required. Sometimes it was used with ordinary loam sand with good results, but sea sand gave the better results.

Cores for the Newton bomb and the chemical shells were made from a mixture of 12 parts open red sand, 24 parts open yellow sand, one part of linseed oil (1 in 37). This mixture was passed through a mechanical riddle and afterwards moistened to the proper texture with water. The core was dipped in blacking while green and hung on rods in the stoves for the night.

There were many advantages in using oil and sea sand for the cores. Among them he enumerated the increasing number of cores produced, the small amount of irons, wires and vents required, the ease with which the cores were removed from the castings, the small number of broken cores returned from the moulder. The chief disadvantage was that the cores would not stand handling in the green state. In order to overcome this difficulty it was essential to have every assistance from the pattern shop, and in the case of the jobbing foundry, an agreement with the customers as to the manner in which the core-boxes were prepared.

One class of work which lent itself particularly to this method was valves of almost any type. One half of the core was made first, dried, and then used as the plate or support for the other half. The dried half was smeared with a thin coating of gum on the joint. In the case of large heavy cores, the half which was dried first should be the bottom half in the mould, and should contain the core irons.

Where the core was of an irregular character and in the ordinary way would necessitate much preparation in making core irons it was often possible to make the core in two or more pieces by parting the cores on a plain section and then proceeding, as in the case of valves, by putting the wet halves on the dried halves. In all cases possible the core-boxes should be made just frames which were collapsible, with rebated ends held together by bolts and winged nuts, so that no rapping with heavy mallets or hammers was necessary.

An objection to the use of oil was the offensive smell. This applied especially to fish oils, and unless really good ventilation, such as by fans, was provided to draw away the gases, complaints regarding it were justified. Linseed oil had an unpleasant odour and was expensive, but it was generally accepted as the ideal binder, and remarkable results were obtained with it. To his mind, the ideal oil would be one which gave off the minimum gas and smell, and retained the properties of linseed. In all oil-sand mixtures it was essential to watch carefully the thorough mixing of the required proportions, which might vary from one of oil and 30 of sea-sand to one of oil and 60 of sea-sand. The governing factor was the class of core. Where heavy sections were in question a slight addition to the oil content was usually beneficial. With small work and light sections no blacking was necessary.

He had heard it stated that oil cores would not take blacking, but during the war cores for the casting of 112-pounder aerial bombs were made of oil-sand and dipped in blacking after being dried and dressed, without a single reject from the core.

The results obtained on general jobbing work were consistently good. Cores varying from one ounce up to 6 or 7 cwt. were used for castings weighing from a few ounces up to 15 tons. A slab of oil-sand core placed on a pattern and rammed up in the mould made an ideal support

XUM

for stud chaplets and would carry any amount of weight. Again in many castings such as bed plates for engines and heavy machinery, where there was a chequer or diamond pattern on the bottom of the mould, which under ordinary conditions would require a lot of sprigging and venting, all that was necessary was to make a plain print, and just a section in a slab core-box of the pattern, then, after the mould was finished, these cores could be placed in position and just sprigged or rammed tight. There was then practically a dry-sand bottom, and the danger of scabbing and washing was practically eliminated.

When the casting was of such a design as to cause abnormal contraction stresses to be set up, oil-sand cores were invaluable. As soon as the metal was set, beyond retaining the heat these cores were absolutely friable and offered no resistance whatever to the contraction, and if it was necessary to remove the core only a few minutes work was necessary. The cores could be rubbed to any shape desired without losing their smooth surface, as the structure was absolutely uniform.

There were different opinions as to whether sea sand should be used wet as it was brought from the coast. Some people advocated drying before mixing the oil and afterwards adding sufficient moisture to give the required texture. Under any circumstances he should recommend that the sand be kept under cover, because if there was too much moisture before the oil was added it was much more difficult to get a thorough mixture. There was also a difference of opinion as to the heat required to dry oil-sand cores. He thought the size of the cores was the governing factor. Very satisfactory results were obtained if the cores were dried fairly quickly and slightly more heat applied than with loam-sand cores of corresponding size. But these were small difficulties which would be got over by a little experimenting.

Discussion.

Mr. Roe asked what kind of oil the lecturer had used, the proportions in which it was mixed with sand, and the price.

Mr. Masters replied that he used ½ pint of linseed oil at 120s. per cwt. and ½ pint of "Tax" oil at 112s. 6d. per cwt. to 45 pints of sea sand. He had tried "Tax" alone.

Mr. Sherburn asked what happened to the sand. How much oil-sand would there be in the 45 pints. In view of the difficulties of transport, etc., he thought it was very important to try to use the materials over and over again.

Mr. Masters said they had done so, but afterwards it was more troublesome to mix. The cost of the sea-sand was between 10s. and 11s. a ton. It was more beneficial than otherwise that the sea-sand should mingle with the ordinary floor sand. In any foundry where oil-sand cores were used in quantity, there were few scrapped castings. Through the sand becoming saturated with the oil, one got a better skin on the castings and the blue shine that people liked to see.

Mr. Sherburn remarked that he was informed by a firm of sand merchants that the railway companies were refusing to allocate wagons for sand. If that was going to be the position, what was the foundryman to do?

Mr. Masters said the old stuff could be used again, or black sand, but it was more troublesome to mix, and thorough mixing was essential. In his own case the mixing was done not mechanically, but by hand, and the stuff was passed through a riddle. If he could find a machine that would produce the desired result he would use it.

Mr. Roe said the trouble with machines mixing sand of this description was that they knocked up very easily through oil adhering to the working parts.

Mr. Hill suggested if the oil was emulsified it spread better through the sand and the quantity needed was less.

Mr. Key said the emulsifying method of applying the oil was best, because the oil was thinned to a certain extent and it could be distributed better. The best mechanical appliance was a riddle with a series of small weights which would rub the sand after it had been moistened with the emulsion. For some purposes old sand would do just as well as new. Some little time ago his firm had trouble with phosphor bronze, and got better results altogether by discarding the sea-sand and using ordinary dressing shop sand. He had no doubt the mixing could be done mechanically; mixing by hand was very expensive.

Mr. Sherburn said these things must be dealt with scientifically and it did not seem to him scientific to put a solid mass of oil in sand and then try to mix it up. It would be far better to adopt some method of finely dividing the oil. The object was to get every grain of sand covered with a particle of oil, and if it could be attained by emulsifying and spraying, far better results could be got.

Mr. Miles remarked that necessity was the mother of invention, and if oil-sand cores were more extensively used a mechanical mixer would be invented; but at the moment only small quantities were made at a time, because what remained at the end of the day was no good; the sand formed a crust on the outside of the heap. If that could be prevented by emulsifying, the mixing could be done in the sand-mixing department, but at the present time the practice was to mix in the core shop on the bench.

Replying to other questions, Mr. Masters stated that he did not put in ashes. The inside of the core was made of black sand. There was no necessity for more than an inch and a half of a wall of sea-sand round any core, provided a grid was put in to carry the core. In the dressing shop they got the core ends back without any damage.

Mr. Roe: We know you cannot ram the sand. Do you allow anything for shrinkage in the core?

Mr. Masters replied that it was not necessary. If the pattern-maker could be persuaded to make a collapsible box there would be no difficulty. On light sections there was no necessity to black oil-sand cores; with heavy sections, if the cores were blacked warm they got a better setting. The maximum thickness he would go up to without blacking the core on smooth sections was not above an inch, for bearing pedestals or anything of that sort.

Mr. Key said he had read in a report on American practice that one hour's drying at 500 deg. was equivalent to 24 hours drying at (he thought) 275 deg. In his own practice he found he could dry in almost any heat, and that the intensity of the heat determined how long the cores should be left in the stove. If they were left in the stove all night at a heat above 400 deg. there might be trouble in the morning, but if the cores were watched, the drying could be done at

considerably above that temperature. The best results were obtained when the cores were put in a red-hot stove during the day, taken out as soon as they get to a dark brown and were smoking, and then allowed to cool themselves out.

MR. MASTERS: I take it that refers to light cores.

MR. NICKOLLS asked whether boiled linseed oil was used.

MR. MASTERS stated that boiled linseed oil gave quite good results. It caused, however, smarting of the eyes, especially if the foundry was one of the old type.

MR. HILL said from what he heard he gathered that linseed was the best kind of oil; but after casting it began to smoulder and become offensive.

MR. MASTERS suggested that in such a case there was an excess of oil in the first mixture.

MR. HILL said even after getting the right amount it smouldered, then if the casting was disturbed, if it was pulled out of the sand, it would light up again.

MR. MASTERS replied that it showed the oil was not being driven off. It occurred quite consistently in making the aerial bombs, and they kept a man going round keeping them alight. Linseed oil was the best binder without exception, and, apart from the smell, there was nothing detrimental about it. They had no men off sick during the time they were using linseed oil. To prevent the sand sticking to iron core-boxes, they should be wiped out with a piece of waste and occasionally touched up. Paraffin lubrication would remove any stickiness.

MR. SHERBURN remarked that it was not altogether effective, sand sticking to the boxes was a real difficulty.

MR. HILL said Mr. Masters spoke of the old sand getting in the core-sand heap and improving it. In his own case with castings not so big as Mr. Masters mentioned, he found that after a certain time the sand got full of oil and could not be manipulated; it was not suitable for the purpose in view. After using it, say, for a few months they had to clear out the whole heap.

MR. HOGG asked how the lecturer would account for scabbing on castings such as bombs and shells. He had seen that on numerous occasions both with sea sand and black sand.

MR. MASTERS said he thought they were isolated patches of oil on the surface; when the metal touched them, it set up a fusion just like an iron scab. A lot of it would come off. As a matter of fact they cast 23,000 aerial bombs and never had a scab. The cores were dipped in plumbago blacking which gave excellent results.

THE CHAIRMAN (Mr. Meadowcroft) asked with regard to emulsifying the oil, did that take away part of the bond? Would it be as strong in binding as before emulsifying?

MR. SHERBURN: It is only a mechanical subdivision of the particles.

A vote of thanks to Mr. Masters was passed unanimously.

THE business hitherto carried on by Pullan & Mann, makers of brick, tile, and sanitary-pipemaking machinery, of Leeds, has been acquired by the Brightside Foundry and Engineering Company, of Sheffield. The services of Mr. Mann and some of his staff are being retained by the company, which has erected a foundry and machine shop at Eccleafield, near Sheffield, for the manufacture of brickmaking machinery.

Semi-Steel.

By W. J. EVANS.

It is necessary to remember that so-called "semi-steel," or steely mixture, is nothing more or less than good cast iron, which if properly used is suitable for many purposes. No claim is made, or should be made, that castings made from this particular mixture of iron are more ductile, or malleable or of greater elasticity than ordinary grey-iron castings; but there is a considerable increase in the tensile and deflection tests, also the finish from the machining operations is much better, owing to the closer grain of this particular material. It is possible to increase the tensile of an ordinary mixture from, say, 10 tons to 16 tons. The same results can be obtained by the use of cold-blast hematite and the expensive irons, but the use of steel gives more uniform results without anything like the costs, and this to-day is one of the most serious items foundrymen have to face.

There are two methods of adding steel to cast iron; (1) by placing borings, punchings, or light scrap in the ladle, and (2) by charging direct into the cupola. The first method is not satisfactory, as the fact of putting the cold steel into molten iron brings down the temperature and involves one of the most fruitful sources of trouble in the foundry, the use of stiff metal. The second method is the more satisfactory; that is, charging into the furnace with the pig-iron and scrap. If the cupola is properly worked this will give a fairly even mixture, and the molten iron will be at a high enough temperature to run and cast the thinnest of sections.

We invariably use mild-steel scrap of 0.1 to 0.4 carbon, which consists of boiler-plate shearings, pieces of angle iron, tees, channel, etc. We charge into our cupolas steel scrap up to 2 ft. long. We always try to avoid the use of very small steel scrap, as this is a fruitful source of uneven mixtures, through the small pieces of steel dropping through the coke into the hearth of the furnace, as it is very likely to give hard and also soft castings from the same heat.

The use of small scrap has been our chief source of trouble, and at one period we were not able to get suitable material, and had to use old rivets and bolts. On no account do we use old files, of anything of a similar nature high in carbon, as we feel sure this melts too quickly for the rest of the charge, and again gives uneven mixtures.

Our own experience shows that this particular iron has given better results for our class of castings than any previously used, that it is much cheaper, and can be used by any foundryman who likes to try it.

We use three or more brands of pig-iron to minimise any difference in the silicon content of any particular consignment. We always buy iron with from 3 per cent. to 4 per cent. of silicon, which we have no trouble in obtaining. Of course this will not be necessary in many cases, if one is manufacturing castings of heavier sections than we are. Practically any foundry number of pig can be used and one can increase or decrease the percentage of steel to suit any castings being made. The following is an approximate analysis of one of the pig-irons we are using:—Si. 3.5, P. 1.4, Mn. 0.46, S. 0.007. This particular pig-iron is low

* Read before the East Midland Branch of the Institute of British Foundrymen, Feb. 28, 1920.

in sulphur, with an average of manganese, and rather high in phosphorus. We do not, as a rule, use irons high in Mn., or ferro-manganese, as in our case this would most likely give hard castings, as Mn. retards the formation of graphite. The same applies to sulphur, and for this reason we keep both as low as possible. The phosphorus is rather high, but this suits our purpose, as most of our castings are of extremely light sections and difficult to run. For heavier sections the phosphorus would be better lower.

We always use scrap from the previous day's melt from the same mixture, and not from the scrap pile; in fact we do not buy cast-iron scrap, the only scrap pile being the steel scrap. We are using about 50 per cent. of two or three brands of pig, and 25 per cent. of semi-steel scrap. This, however, would not be suitable for all classes of work. The steel scrap should be adjusted to the thickness of the castings, also the pig-iron being used. We take an analysis of our mixture each day, also tensile and deflection bars through the heat. We also cast bars for fracture. These bars are cast from patterns of different thicknesses 12 in. long, 2 in. wide, ½ in. thick, and increasing by ½ in. thickness up to ¾ in. In other words we cast fire bars of the same length and breadth, but of increasing thickness in the same box part, running them from the ends on the same runner. The bars are cast at intervals through the cast, and represent certain batches of castings. The next day these bars are broken, and if any of the fractures are white of a certain thickness, all castings in the batch which these bars represent of this same thickness or under are carefully inspected before despatch. This is a good guide as to whether the cupola is working properly, and that the materials charged are being properly weighed out. This is a very simple method for anyone to adopt who cannot charge his cupola by analysis, as it is possible to commence with, say, 10 per cent. steel, and by the result of the fractures find out how much steel can be used in the particular castings required, or how much steel the pig being used will carry without hardness. I have made castings with as much as 60 per cent. of steel in the mixture which have machined such as blocks for drop stamping.

No special type of cupola is necessary, and as far as I can see any furnace properly worked will give good results. We ourselves are using very old cupolas—perhaps 50 years old. There is no special method of charging other than that commonly used. The pressure of wind we use is about 12 in. water-gauge, and perhaps better results are obtained with large tuyeres, and soft blast than otherwise. We also use a little ferro-aluminium as a deoxidiser; this also helps graphitization. As our charges in the furnace are of about 20 cwts. each, we try to tap out a full charge each time, and keeps a ladle in its capacity, as a rule, under the spout. This is also to keep the mixtures as even as possible, and when a cupola-man knows his furnace he can gauge this fairly well.

The chief source of trouble in the foundry is the temperature at which metal is poured. It is absolutely essential to pour all castings from this mixture as hot as possible, no waiting for metal to cool, or placing of heads in the ladle. Using this semi-steel as hot as possible gives the best results; also by doing so it is possible to get softer castings, as it prolongs the rate of cooling. One should not, of course, go to the extreme and cast a solid block some tons weight as hot as possible; but for the ordinary run of castings, it is necessary to cast hot.

It is also important to have large enough heads on the moulds, well bushed up, to cast more or less under pressure. It is also desirable to avoid all feeding with rods, as this should not be necessary unless the castings are of a very uneven thickness. We had considerable trouble to get our moulders to bush up their work; they would use shallow bushes; and very often scrap a casting.

Most remarkable is the difference in the form of the graphitic carbon in the semi-steel, compared with that of an ordinary cold-blast hematite cylinder iron. It is much more finely divided in the semi-steel than in ordinary iron. There are practically no lines of weakness due to continuous flakes of graphite, nor is there likely to be much trouble under water test. It wears well in most cases, and for gears and hydraulic cylinders and pipes is first class; and, as before mentioned, is strong and if properly manufactured lends itself to easy machining with good finish.

We do not use a high silicon iron for the sake of using it, but to control the mixture, as in our particular class or work, with intricate and thin castings, and much machining to be done with expensive filling cutters, we must have castings that machine easily and a mixture that will not easily chill. What is wanted is a thorough graphitisation of the entectic. This should take place late during solidification or, better still, after. This can only be obtained by a high enough silicon content. With castings of thin sections, which must of necessity cool quickly, silicon is better for the formation of graphite. The average analysis of our semi-steel is:—Si. 2.35, S. 0.051, P. 0.63, Mn. 0.76, GC. 2.66, CC. 0.64, which is practically identical with the Scotch analysis. The tensile strength of this material is almost always over 16 tons per sq. in.

DETERMINATION OF NITROGEN IN STEEL.—N. Tchishevsky, a member of the Russian Metallurgical Society writes: The most precise method of estimating nitrogen in steel or iron is the following: — Five grammes of steel or iron are dissolved in hydrochloric or sulphuric acids, and the ammonia evolved is determined by titration with N/100 sulphuric acid. Experience has shown that the distillation tube should be made of silver or tin, and not glass, the latter having an influence on the basicity of the solution.

WORLD'S OIL OUTPUT. — According to "The Petroleum Times," the total crude oil output of the world in 1919 constitutes a record, amounting to 557,491,239 barrels. The following are the figures for the different countries in 1919 with those for 1918 (added in brackets) for comparison: United States, 377,719,000 (355,927,716); Mexico, 87,359,436 (63,828,327); Russia, 34,284,000 (40,456,182); Dutch East Indies, 15,780,000 (13,284,936); Rumania, 6,352,929 (8,730,235); India, 8,453,800 (8,000,000); Persia, 8,320,000 (7,200,000); Galicia (Poland), 6,255,300 (5,591,620); Peru, 2,560,000 (2,536,102); Japan and Formosa, 2,120,500 (2,449,069); Trinidad, 2,780,000 (2,082,068); Egypt, 2,548,000 (2,079,750); Scotland, 2,048,000 (2,032,000); Argentina, 1,504,300 (1,321,315); Germany, 925,420 (711,260); Canada, 220,000 (304,741); Venezuela, 245,300 (190,080); Italy, 38,254 (35,953); other countries (about) 25,000 (20,000). The total output in 1918 was 516,801,354 barrels.

Pressure Due to Fluid Iron in Moulds.*

By C. Webster.

The writer proposes to discuss the influence of the pressure of fluid iron in straining, bursting and lifting of moulds; and the pressure on the bottom, sides and underneath the top part or covering plates, also on the cores or those parts of the mould which are either wholly or partly submerged in the fluid iron.

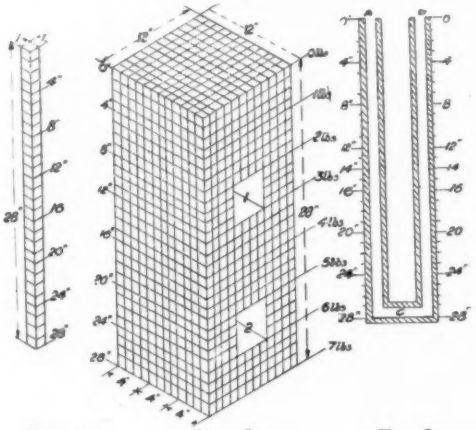

FIG. 1. FIG. 2. FIG. 3.

Let us compare fluid iron with water. Fig. 1. is a column 1 in. square and 28 in. high. A column of water of these dimensions would weigh about 1 lb., and if poured into a vessel of similar dimensions placed in a vertical position would exert a pressure of 1 lb. per sq. in. on the base of the column. A fluid takes the shape of the vessel which contains it, and exerts pressure in all directions; so there would be not only a pressure of 1 lb. per sq. in. on the base, but also a similar pressure at the bottom of each of the four sides of the column. Beginning at the top, the pressure gradually increases from nothing to 1 lb. per sq. in. at the bottom.

If we wish to know the total pressure on each side, we take the area of one side, which is 28 in., and multiply this by the mean pressure, ½ lb. per sq. in. which would=14 lbs.

Comparing fluid iron with water, we find that its specific gravity is seven times that of water; or bulk for bulk, it is seven times heavier. For the sake of convenience we will take a cubic inch of iron as weighing 0.25 lb. instead of 0.26, as this will make the calculations more simple. If a cubic inch of iron weighs ¼ lb., then we only require 4 cub. in. for 1 lb. In water we require 28 cub. in.

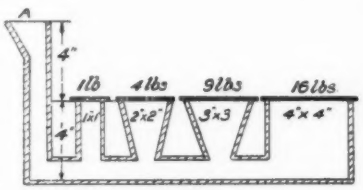

FIG. 4.

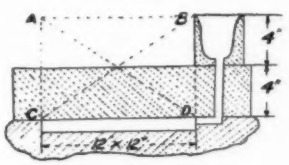

FIG. 5.

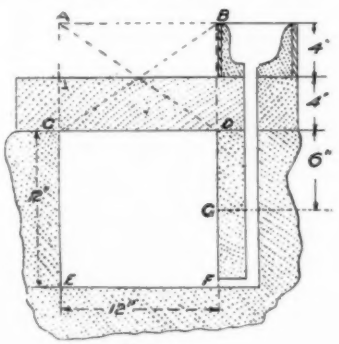

FIG. 6.

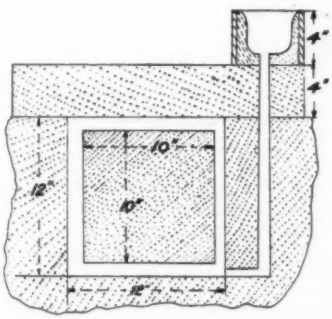

FIG. 7.

A mould similar to Fig. 1, 1 in. sq. and 28 in. deep, placed in a vertical position would require 7 lbs. of fluid iron to fill it, and as this would rest on an area of 1 sq. in., there would be a pressure of 7 lbs. per sq. in. With water we require a head of 28 in. to produce 1 lb. per sq. in.; with fluid iron 4 in. head.

Fig. 2. is a prism 12 in. by 12 in. by 28 in. Instead of having one column 1 in. sq. and 28 in. deep, we have 144 such columns, which, if consisting of water, would weigh 144 lbs., standing on a

* Read before the Sheffield Branch of the Institution of British Foundrymen, Feb. 20, 1920, Mr. J. R. Hyde in the chair.

base, 144 sq. in. in area, and exerting a pressure of 1 lb. per sq. in. as in Fig. 1. Thus it is seen that a head of 28 in. of water always produces a pressure of 1 lb. per sq. in., no matter whether the base be small or large.

Taking now fluid iron in a mould of similar dimensions, the pressure on all portions of the mould would be seven times that of water, or on the base of the prism, Fig. 2, 1,008 lbs. The

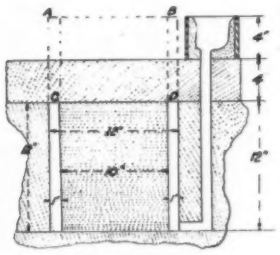

FIG. 8.

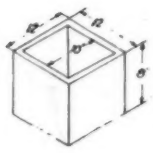

FIG. 9.

pressure on each side would be 1,176 lbs. or, depth 28 in. by width 12 in. by 3½ lbs. mean pressure on the side.

Fig. 3 is a U-shaped vessel, 1 in. sq. and 28 in. deep. Fluid poured in at A would rise in B until both were full. If it were a mould and filled with liquid iron, and B were cut off at 4 in. down, a cover placed on, A again filled, we would get a pressure under the cover of 1 lb. or equal to a column of iron 1 in. sq. and 4 in. deep.

Reverting to Fig. 2, we see the influence of fluid iron on cores. In the centre of the third row of

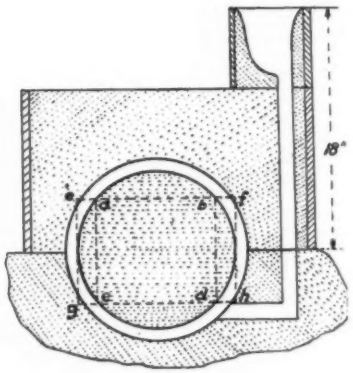

FIG. 11.

cubes we have a hole 4 in. square passing right through the prism. A body of less specific gravity placed in the fluid, floats and floats in such a way that it displaces liquid equal to its own weight. If its specific gravity is greater than that of the liquid, it sinks. In the case of the lighter body, the pressure that forces it to the surface of the fluid is the weight of fluid displaced minus the weight of the body.

Take this 4 in. by 4 in. by 12 in. as a sand core. The metal displaced would equal 48 lbs. The weight of the core would be about 12 lbs. Thus 48 lbs. total weight of metal displaced minus 12 lbs. weight of sand core would equal 36 lbs., the pressure tending to float it.

This upward pressure always remains the same no matter whether the core be high or low in the mould. The total pressure on all sides of the core increases the further down it is placed in the mould; but the pressure which is tending to float it remains the same.

Fig. 4 shows a mould, A being the runner basin

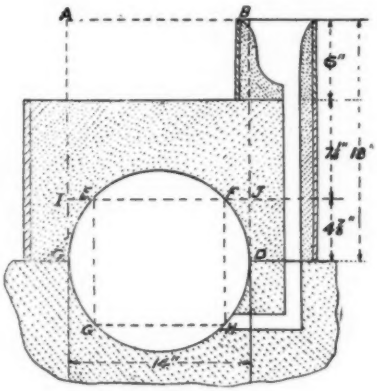

FIG. 10.

8 in high. The first branch is 1 in. sq., the second 2 in. by 2 in., the third 3 in. by 3 in., and the fourth 4 in. by 4 in. The distance from the tops of the branches to the top of the runner basin is 4 in., or equal to 1 lb. per sq. in. pressure. As branch No. 1 has only an area at the top of 1 sq. in. the pressure underneath it would be 1 lb.

Branch No. 2, with area of 4 in., would have a force underneath the cover of 4 lbs.; at No. 3, with

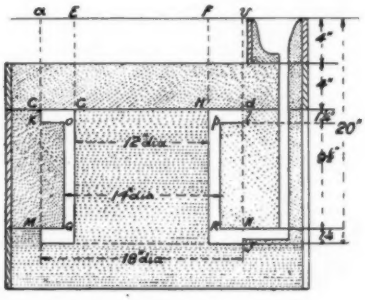

FIG. 12.

9 sq. in., the pressure would be 9 lbs.; and at No. 4, with 16 sq. in., the pressure would be 16 lbs.

To find the lift underneath any particular top part, first find the area against which the fluid iron presses and multiply this by the height of the iron in the runner basin. This gives us the number of cubic inches of iron equal to the pressure under the top part.

Fig. 5 is the section of the mould, of a plate 12 in. by 12 in. by 1 in. from the top of the runner basin to the joint of the moulds is 8 in. or=2 lbs. per sq. in. The pressure under the top part equals 288 lbs., due to the head 8 in., or equal to a block

of iron 12 in. by 12 in. by 8 in. The pressure on the bottom would be 2¼ lbs. per sq. in., or the area of the bottom is 144 sq. in. which multiplied = 324 lbs.

The pressure on each edge of the plate equals 12 sq. in. by 2 lbs. pressure per sq. in., or 24 lbs.

Fig. 6 is a section of a 12-in. cube. The pressure under the top part is the same as in Fig. 5, because the head of fluid iron and the area against which the metal presses is the same.

The pressure on the bottom would be that due to a head of metal 20 in. high or 5 lbs. per sq. in.

Fig. 10 is a cross section of a mould 14 in. dia. and 12 in. long. The top part is 12 in. deep and the runner basin 6 in. deep. The lift under the top part would equal a block of cast iron, the sectional area of which is equal to A, B, C, D, minus the area of a 14-in. dia. semicircle. Or, taking the largest square we can inscribe in a 14-in. dia. circle, which would be about 9 ft. 8 in. as at E, F, G, H, then producing the line E and F to I and J, which would be about 4⅞ in. above the parting line C D; to find the lift under the top part, multiply the length of the line I J by 12 in.

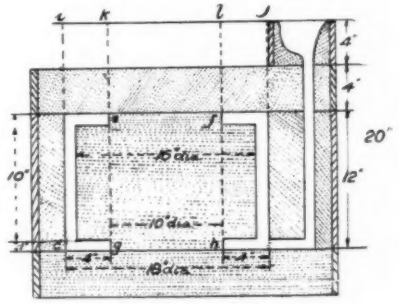

Fig. 13.

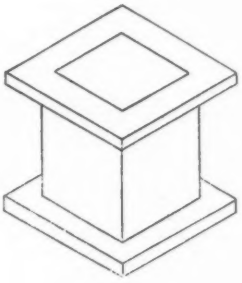

Fig. 14.

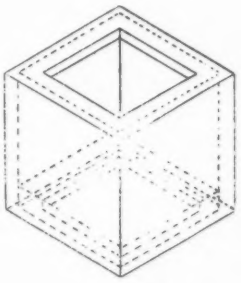

Fig. 15.

On each side, with an area of 144 sq. in., there would be pressure equal to the mean height of the side, or 6 in. plus the head in the riser, totalling 144 sq. in. by 3½ lbs. mean pressure, or 504 lbs.

Fig. 7 is a box similar to the one shown at Fig. 9, but 12 in. by 12 in. by 12 in. The 10 in. by 10 in. core passes right through. The pressures in this case under the top part on the bottom and two of the sides are exactly like those in Fig. 6. The lift under the core equals the amount of liquid iron displaced, 10 in. by 10 in. by 12 in., or 300 lbs., minus the weight of the core. There

(the length of the mould) which gives an area of 168 cub. in. This by 3½ lbs. per sq. in. shows the pressure due to a head of fluid iron from J to B, namely, 13⅛ in. The result would be 546 lbs., or a block of iron the sectional area of which is A B, I J, and 12 in. long. The pressure on the bottom would equal a block of iron A, B, C, D, with half the area of a 14-in. dia. circle added to it.

Fig. 11 is a mould similar to Fig. 10, except that it has a 12-in. dia. core passing through the centre. To find the lift under the core, we multiply the area of a 12-in. dia. circle by the length of the

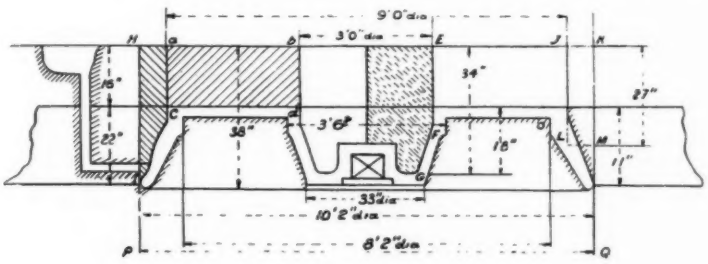

Fig. 16.

is 2¼ lbs. per sq. in. pressure on the top of the core, and 4¾ lbs. per sq. in. on the underside.

Fig. 8 is a similar box with open ends, top and bottom. The pressures under the top part and on the bottom are the same per sq. in. as in Figs. 6 and 7, but the areas are much smaller. Under the top part we get 44 sq. in. by 2 lbs. per sq. in. or 88lbs. The area of the bottom is also 44 sq. in. by 5 lbs. per sq. in., or 220 lbs.

The side pressure would be exactly the example Fig. 6.

The pressure on the four sides of the core would be the same per sq. in. as on the outside at the same depth, but the area would be smaller or less.

mould, and thus find the number of cubic inches of iron displaced, or if we find the largest square that can be inscribed in a 12-in. dia. circle A, B, C, D, then form the rectangular figure e, f, g, h (about 12 in. by 8½ in. = 102), then 102 by 12 in. length of core gives 1,224 cub. in., or 306 lbs. total pressure under core.

Fig. 12 is a 12-in. dia. pipe cast on end. The pressure on bottom equals the area of the flange by 5 lbs. per sq. in. The pressure under the top part equals the area of top flange by 2 lbs. per sq. in. The lift due to the metal displaced between the flanges would equal a ring of iron M, N outside dia., Q R inside dia., and O to Q deep.

XUM

Fig. 13 is a pipe with internal flanges. The pressure would be similar to those of Fig. 12, except that we get the lift under the core instead of outside.

Figs. 14 and 15 are square instead of round, as in the case of Figs. 12 and 13.

Fig. 16 is a section of a grinding pan with runner basin 16 in. above the top joint. The lift under the outside from I to C would equal a ring of which the sectional area would be H, I, C, A (H K outside dia. and A J inside dia.). The lift under the top from C to D would equal the area of that face, multiplied by 4 lbs. pressure per sq. in., or a block of iron of A J outside dia. and B E inside dia. The lift under the centre portion would equal a block of iron half of which is shown in section.

Discussion.

THE CHAIRMAN (Mr. J. Hyde) commented on the necessity of considering the laws of liquid pressure when producing castings. A practical moulder often had an idea that his way of making a job was better than that of the pattern maker, though he might be at a loss to explain why; but, after what the lecturer had shown, he began to think that the practical moulder who had made observations was very often right.

MR. F. DARLEY said he had seen some disastrous accidents, especially in iron foundries, simply through the subject of pressures not being understood. No matter what the area, the pressure per square inch was governed by the height of the head.

MR. T. BROWN said the subject had not been considered by moulders in general, who usually practised by rule of thumb, put a weight on the mould, and thought that was enough. In iron casting they did not put very big heads on or big pressures; but in steel casting they sometimes had to go as far as 3 ft. 6 in. and 4 ft. high, and he was afraid that if Mr. Webster worked on the principle of one pound for every four inches in the height of his head, he would be in some difficulty. A fortnight ago he (the speaker) cast a job, which was a plate 16 ft. by 7 ft. in area. it was filled up to 3 ft. above the top of the plate, and on top of the box and weights was a weight of 115 tons. The pressure with 3 ft. of head lifted that box, and he had to stop teeming. He had cast another job with a little more area, and in order to make sure he put 250 tons on it. However, it was very necessary for foundrymen to go into these matters, though there were very few that did so. The results of miscalculations were very serious. They might think they wanted a light core, without realising the pressure that it had to stand, and thousands of castings were made wasters through the foreman moulder not making his calculations when making his core.

THE CHAIRMAN asked whether the castings that Mr. Brown had referred to, which shifted the plate, were cast over a lip or through a nozzle.

MR. BROWN said they were cast through a nozzle, but, as far as pressure was concerned, it was immaterial.

THE CHAIRMAN asked if Mr. Webster had observed how long a casting an inch thick remained liquid after being poured at a medium pouring temperature.

MR. WEBSTER, in reply to the discussion, said he was not going to tell Mr. Brown how to weight steel castings, as he had never had anything to do with them. But what he had stated in his lecture was something that he had seen put into practice nearly every working day for the last thirty years. The figure that he had used was somewhat under the mark, for, as he had stated, he assumed a quarter of a pound to the square inch for the sake of simplicity, but that should be increased by at least a 25th. But he made many castings in accordance with the principle he had laid down, and had found that there had been just enough weight. He could not tell Mr. Hyde how long it would take a certain thickness of casting to cool, nor had he ever given any consideration to the question of the skin of metal setting before the other part. But, on the point of losing castings, his firm had not lost a casting of any size through insufficient weight for the last twelve or thirteen years.

COMMANDER JACKSON, in proposing a vote of thanks to Mr. Webster, said it occurred to him that, with regard to mould boxes being insufficiently weighted and lifting, very often the gas pressures had something to do with it.

RELATION BETWEEN MECHANICAL HARDNESS AND GRAIN SIZE OF CARBON STEELS.—According to the American Bureau of Standards there is no simple relation between grain size and hardness in carbon steels such as exists, for example, in the alpha brass and other one-constituent alloys. Grain size is a factor of minor importance. The amount of distribution of the structural constituents determines the hardness to a far greater extent. The work already completed throws some light incidentally upon the magnitude of the stressing of low-carbon steel by cooling and work in order to effect the subsequent growth of grain upon annealing below the critical temperature. It is planned to extend this investigation to include a study of the effect of grain size upon other mechanical properties.

FACTORY LIGHTING AND MASS PRODUCTION.—The importance of good factory lighting is discussed by a writer in a current issue of "Electrician." It is essential that the artificial lighting should be scientifically designed and fully adequate, and the fundamental principles of good industrial lighting were outlined in the report of the Departmental Committee of Lighting in Factories and Workshops. It is possible to state in general terms the amount of illumination necessary for different classes of work, and the following table is put forward tentatively as indicating good modern practice :—

Nature of work.	Minimum illumination. (Foot-candles.)
In passages, store rooms, etc., and places where illumination is only needed in the interests of safety and general convenience	0.25
Very rough work, not involving close inspection, but only the handling of large objects	0.5 to 1.0
Rough manufacturing operations such as assembly, bench work, etc., and very simple clerical work	2.0 to 3.0
Fine manufacturing operations	3.0 to 5.0
Very fine work (such as engraving, accurate metal work, special draughtsman's work or work on dark materials)	5.0 to 10.0

The figures given are suggested *minima*, and it may well be that in some industrial operations they might be exceeded with economical advantage; but a point to be specially noted is the influence of the colour of materials of manufacture. This point is discussed with reference to the best form of lighting arrangements for various special classes of work.

Trade Talk.

An amalgamation has been arranged between Perkins Engineers, Limited, and Joseph Baker & Sons, Limited.

The directors of the United Steel Companies, Limited, are about to build a new dock at Workington to take boats up to 5,000 tons.

Bradley & Burch, Limited, 5, Whittington Avenue, E.C.3, have removed their machinery department to the Imperial Works, Sunnyside Road, Ilford.

Palmers Shipbuilding & Iron Company, Limited, of Jarrow, have taken over the concrete shipbuilding yard established at Amble during the war, and propose to build coasting vessels there.

The Wilson-Wolf Engineering Company, Limited, of Bradford, have appointed Messrs. Pooley & Austin, 34, Broadway, Westminster, S.W.1, as their sole agents for London and district.

Baldwins, Limited, are proposing to acquire from the Salisbury Club Building Club Company, Limited, Swansea, the whole of the freehold premises in Wind Street, Swansea, for the purposes of office extension. Messrs. Baldwins already rent a portion of the premises.

Messrs. A. G. McKee & Company, 167, Upper Thames Street, E.C.4, are supplying the Bengal Iron & Steel Company with a 5-unit Kling-Weidlein patented dry gas cleaner for the company's blast furnace plant at Kulti, Bengal, India.

In view of the importance of motor transport in these times of abnormal railway congestion, it is interesting to note that arrangements have been completed by "Motor Traction," for the setting up of a "Motor Traction Freight Exchange," in the London area, at 20, Tudor Street, London, E.C.4. The Exchange will arrange to work in conjunction with those Exchanges already established, such as Manchester, Liverpool, Birmingham, Bristol, etc., and it is anticipated that further Exchanges will be opened in those towns where circumstances may require it.

The Machine Tool and Engineering Exhibition, which will be held at Olympia in September next, was to have been held in 1916, but on account of the war it has been postponed until this year. The first exhibition was held in 1912, and the fact that eight years have elapsed since the last exhibition of machine tools in this country will mean that more new models and new types will be on view than have ever been shown at any previous exhibition. The whole of Olympia has been booked up for some months past, and the number of separate exhibitors will exceed 200.

Mr. A. G. Hill, sales manager of the Bawden Machine Company, Limited, Toronto, has returned to Canada after making arrangements for the Canadian selling rights of the specialities of Alley & MacLellan, Limited, Glasgow, and the sole licence right to manufacture and sell in Canada the products of the following firms: Robey & Company, Limited, Lincoln; John Thompson, Limited, Wolverhampton; David Bridge & Company, Limited, Castleton, Manchester; E. S. Hindley & Company, Limited, Bourton, Dorsetshire; and Brown Bros. & Bow, MacLachlan, Limited.

John Brown & Company, Limited, are building a considerable number of houses, in every way superior to those to which the workers have hitherto been accustomed, for the men employed at their new steel foundry at Scunthorpe, Lincolnshire. These houses are of the bungalow type, constructed of concrete slabs, while each is provided with its own allotment plot, or garden. An extension of the same idea is, in addition, being carried out by John Brown & Company, Limited, in conjunction with several other firms in the Scunthorpe district, and a considerable estate is being developed there on garden city lines.

The Secretary of the Department of Scientific and Industrial Research announces that the Research Association for the Cutlery Industry has been approved by the Department as complying with the conditions laid down in the Government scheme for the encouragement of industrial research. As the Association is to be registered as a non-profit-sharing company, the promoters have applied to the Board of Trade for the issue of a licence under Section 20 of the Companies (Consolidation) Act of 1908. The Secretary of the Committee engaged in the establishment of this Association is Mr. W. H. Bolton, P.O. Box 49, Sheffield.

The Tees Bridge Ironworks, Stockton, of Pease & Partners, Limited, have lately been closed. There are three furnaces, only two of which have been working for some time. The furnaces are old established, and the decision to close them down has been arrived at in order that alterations and improvements may be made. Two accidents have occurred recently on the gantry, the latter of which resulted in the loss of two lives, and the firm have decided to make a complete overhaul of this portion of the plant. It is expected that the works will be closed for about three months, between 200 and 300 men being affected.

Davy Bros., Limited, Park Ironworks, Sheffield, have concluded agreements with the Morgan Construction Company, of Worcester, Mass, U.S.A., and the United Engineering and Foundry Company, of Pittsburgh, Pens., U.S.A., the Morgan agreement securing to the company the manufacture for several countries (but particularly for Great Britain) of the Morgan continuous rolling mill plant and specialities. The agreement with the United Engineering and Foundry Company concedes to them the Davy Company's licence to manufacture and sell within the United States and Canada on royalty terms the "Davy" patented presses and shears. An area of 27 acres of freehold land has been acquired, close to the Darnall Station of the Great Central Railway (with direct siding accommodation), and extensive modern engineering shops are now in course of erection. It is expected that they will be in partial operation before the close of the current financial year.

The welded motor ship "Fullagar," built by Cammell Laird & Company, Limited, Birkenhead, and the first vessel to be fitted with the "Camellaird-Fullagar" type of main oil engine, has just carried out very successful sea trials. The vessel is unique in that not a single rivet has been used in her construction, the hull being welded throughout, as are also the fuel, lubricating and water tanks. The ship, which is 150 ft. in length, is intended for the coasting trade, and is fitted with a "Camellaird-Fullagar" oil engine of 500 b.h.p., running at a speed of 100/120 r.p.m. The engine has four cylinders of 14 in. diameter, each piston having a stroke of 20 in. and works on the Diesel cycle. Air at a pressure of 1,000 lbs. per square inch is used for injecting the fuel into the cylinders. A 3-stage air compressor is driven from the forward end of the crankshaft.

Lord Askwith has been re-elected president of the British Federation of Iron, Steel, Tinplate and Metal Merchants, with Sir Archibald Williamson, Bart., M.P., Sir W. Watson Rutherford, M.P., Sir Christopher T. Needham, Mr. W. H. Kidston, and Mr. J. Gray Buchanan as vice-presidents. Presiding at the annual meeting recently, Mr J. G. Buchanan remarked that when the Federation was brought into being the whole trading community of the country was suffering very severely from control, and while that control had been largely removed there were still many restrictions which, he thought, might hamper their endeavours to bring business back to normal. No effort would be spared by the council to obtain complete freedom from the harassing regulations still existing and quite unnecessary. It was particularly, perhaps, in the future that the real value of the Federation would become apparent, and he was one of those who anticipated many difficulties and dangers which would have to be overcome before they could return to peaceful trade. The council was considering methods by which the usefulness of the Federation to its members might be increased, but he emphasised the fact that if they were to fulfil their destiny it was necessary that they should represent as nearly as possible the whole body of iron, steel, tinplate and metal merchants in the kingdom.

In the course of their inspection of local industries the Society of Chemical Industry, who recently held a meeting in Newcastle, paid a visit to the extensive works of the Newcastle Alloy Company, Limited, at Rowlands Gill. They were shown over the various departments of the works, including the boiler plant, the electric generating station, the steel furnace plant, the ferro-alloy furnaces and the cuprous oxide plant, the latter being employed in the production of red sub-oxide of copper. The party partook of tea at the works, and in welcoming the visitors, the chairman of the company, Dr. Henry Peile, gave some interesting information regarding the work carried on. He mentioned that during the war the Ministry of Munitions had absorbed the company's entire output of ferro-chrome. Special attention was now being given to the production of low-carbon ferro-chrome, and also to the production of all grades of electric steel, including both high-carbon and alloy steels, for which three large Heroult furnaces had been erected. The company had also erected at Blaydon a plant for the production of the amorphous carbon electrodes required in the operating of electric furnaces, and they were enabled not only to keep their own furnaces going, but also to supply considerable quantities to other works in the country.

In response to a desire that the war savings schemes instituted at the Newham Steel Works, Newcastle, should be continued, the directors of John Spencer & Sons, Limited, have decided in order to encourage saving and thrift and to promote a spirit of interest in the operations of the company, to accept savings deposits from all the employés of the company who may wish to take the opportunity of doing so on the following conditions:—(1) Deposits will be received weekly at the rate of not less than 2s. 6d. per week, which may be paid in cash or by agreed deduction in wages. (2) The total amount will be limited to £200 per head. (3) Every employé desirous of participating in this scheme must sign a form authorising the deduction of the amount he desires to deposit from his wages each week, and the total amount he wishes to deposit. (4) The moneys so deposited will be subject to seven days' notice of withdrawal if required. (5) Interest at the rate of 5 per cent. per annum (simple interest) will be paid on each complete £1 so deposited for each calendar month it remains on deposit, but no interest will be paid on amounts of less than £1 nor for any less period than one calendar month. Such interest will be paid on January 1 and July 1 in each year for the preceding six months, or any less number of completed calendar months, on each complete £1 so deposited. (6) In addition to the foregoing interest at the rate of 5 per cent. per annum, the company will each year pay an additional rate of one-half of the difference between any rate of dividend above 5 per cent. paid to the ordinary shareholders, that is to say, if the ordinary dividend paid to the shareholders is, say, 8 per cent. per annum, one-half of the difference between 5 per cent. and 8 per cent. equal to 1½ per cent., will be paid, in addition to the 5 per cent., to the depositors on each complete £1 standing to their credit for each calendar month it has been so deposited up to June 30 in each financial year. The directors hope this will encourage good timekeeping and diligent working, so that the benefit may be realised by all concerned. At the present time there are some 377 subscribers under the scheme who have subscribed a total amount of £39,770. Under the first scheme War Bonds were purchased to the amount of £15,000. Under the second scheme War Savings Certificates were purchased amounting to £5,000.

The committee of the Association of Consulting Engineers, in their annual report, point out that the war has left its impression on the engineering profession, and its results are leading to many modifications of the old-established methods of carrying out work and of conditions of contract. Owing to the continual alterations in the price of labour and materials there is an increasing tendency to carry out works either by direct labour or on a prime cost and agreed profit basis, and a sub-committee of the Association is at present engaged in drawing up a model set of conditions for use in the latter case, which form it is hoped will be of considerable assistance to members generally. Negotiations are also in progress with the Federation of Civil Engineering Contractors with a view to arriving at an agreement with regard to an "overriding" clause which the Federation desire shall be inserted in all public works contracts of a purely civil engineering nature. The Association has also accepted the invitation of the council of the Institution of Electrical Engineers to nominate a member on to a committee to consider the revision of the Institution's model general conditions of contract for electrical work, and has appointed as its representative Mr. A. H. Dykes, of Messrs. Handcock & Dykes. The council of the Institution are of opinion that in some cases of work in the United Kingdom the engineer would be justified in asking for some reasonable increase in the percentage fee owing to the work seriously exceeding the normal time, owing to unforeseen difficulties with labour and supply of materials. In the case of works abroad the changed conditions are more accentuated, and in these cases the engineer may have to make very serious increases on pre-war rates. For reports, engineers' preliminary work and general advice on engineering matters, they are of opinion that the engineer is justified in increasing his fees by 50 per cent. above pre-war rates. During the year the Association has been asked by the British Engineering Standards Committee to appoint representatives on each of its various sub committees. The following members have been appointed to represent the Association:—Mr. H. R. J. Burstall—Sectional Committee on Pipe Flanges; Mr. H. H. Humphreys—Sectional Committee on Cement; Mr. G. Midgley Taylor—Sectional Committee on Vitrified Ware Pipes; Mr. W. Vaux Graham, Mr. H. J. Rofe, Mr. E. Brough Taylor, and Mr. E. L. Mansergh—Sectional Committee on Cast-iron Pipes; Mr. H. J. Rofe and Mr. E. L. Mansergh—Sub-Committee on Cast-iron Pipes for water, gas and sewage.

Personal.

Mr. F. Kirby has succeeded Mr. E. V. Morgan as secretary of Bell Bros., Ltd.

Estate of the gross value of £67,560 has been left by the late Mr. H. S. Sutton, metallurgist, Glynicros, Neath, Glamorgan.

The late Mr. Stanley Martin, of Ivonhurst, The Firs, Bowdon, Cheshire, steel works manager, late of Cape Breton, N.S., left £10,941.

The gross value of the estate of the late Mr. J. Wallis, joint managing director of Drakes, Limited, gas engineers, Halifax, is £7,433.

Mr. A. H. Redfern, the present managing director of Armstrong, Stevens & Son, Limited, has joined the board of Amalgamated Stampers, Limited.

Mr. J. M. Deschamps, managing director of Australian Electric Steel, Limited, Alexandria, N.S.W., is at present in this country on a business trip.

The late Mr. H. Rose, managing director of Rose Brothers, Limited, Albion Engineering Works, Gainsborough, left estate of the gross value of £38,766.

Mr. E. Williams, of Pontardulais, has been elected a director of the Tredegar Iron & Coal Company, Limited, as successor to the late Mr. F. L. Davis.

Mr. J. T. McCleary has resigned the secretaryship of the American Iron and Steel Institute on account of ill health. Mr. H. Cook, assistant secretary, will undertake the duties for the time being.

Mr. W. Boyd, general manager of Messrs. Swan, Hunter & Wigham Richardson's shipyard at Wallsend, has been elected managing director of Workman, Clark & Company, Limited, Belfast.

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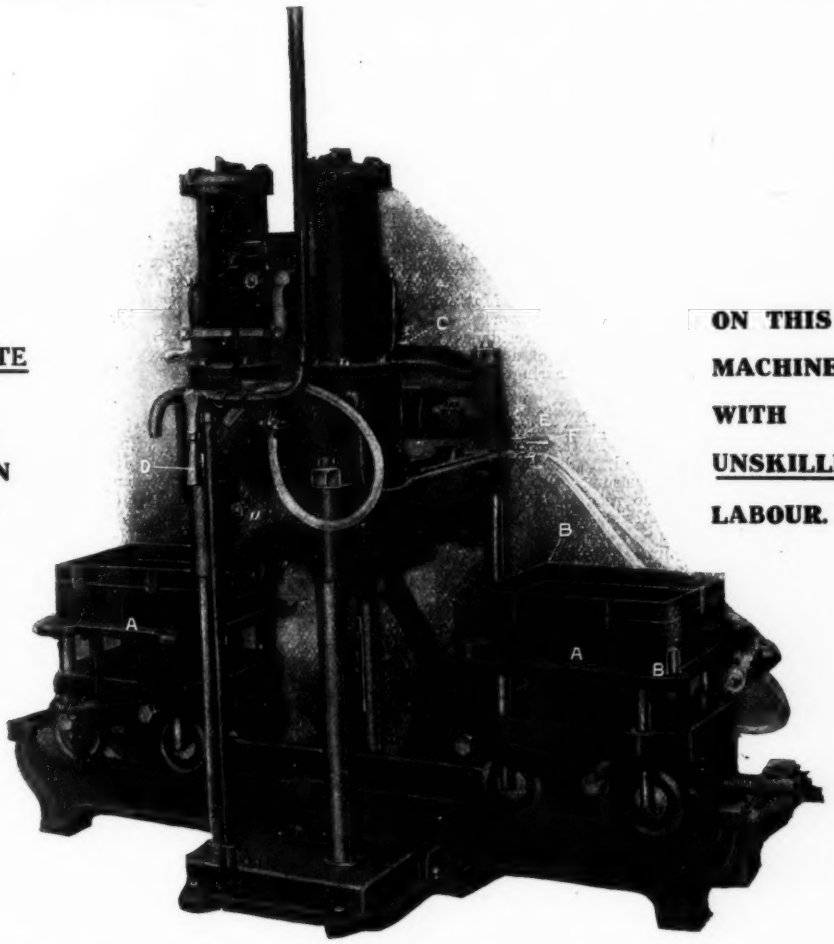

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MR. G. BULLOCK, managing engineer, of the Vulcan Boiler & General Insurance Company, Limited, has resigned, after forty-four years' service, and has been succeeded by Mr. F. H. Bullock, deputy managing engineer.

MR. H. V. TAYLOR, assistant yard manager to Craig, Taylor & Company, Limited, shipbuilders, of Thornaby, has been the recipient of a presentation from the officials and men on the occasion of his recent marriage.

DR. WILLIAM MASON has been appointed to the Chair of Engineering: Strength of Materials, at the University of Liverpool; and Mr. C. O. Bannister, Associate of the Royal School of Mines, to the Chair of Metallurgy.

MR. G. B. BROOK, of the Sheffield University, has been appointed chief chemist to the British Aluminium Company, Limited. Mr. Brook is at present lecturer in charge of the non-ferrous metallurgical department of the University.

MR. G. E. SANSON, one of the officials at the Britannia Works, Banbury, of Samuelson & Company, Limited, who has completed 50 years' continuous service, has been the recipient of presentations from the directors and staff.

MR. W. E. WALKER, managing director of the Vulcan Company, of Southport, has left England for New York on the s.s. "Celtic." Mr. Walker intends to make a considerable tour in Canada studying local trade conditions on behalf of his company.

MR. J. V. SPARROW, who for the past fifteen years has been representing the General Electric Company, Limited, at Cardiff and Swansea, has now resigned, to take up an appointment with Cooper & King, Limited, 37, Westgate Street, Cardiff.

MR. A. CARRINGTON, a director of Markham & Company, Limited, Broad Oaks Ironworks, Chesterfield, who is leaving to take up his residence at Bournemouth, has been the recipient of a presentation from the officials and men. Mr. Carrington will retain his seat on the directorate.

THE LORD PRESIDENT, as President of the Committee of Council for Scientific and Industrial Research, has appointed Dr. J. S. Flett, at present Assistant to the Director in Scotland, to be Director of the Geological Survey and Museum. Dr. Flett succeeded Sir Aubrey Strahan, who retired last month, when Mr. G. W. Lamplugh, Assistant to the Director in England, also retired.

PROFESSOR SIR JOHN CADMAN, K.C.M.G., D.Sc., University of Birmingham; Mr. W. B. Hardy, Soc. R.S., Gonville and Caius College, Cambridge; and Professor Sydney Young, D.Sc., F.R.S., Trinity College, Dublin, have been appointed, by an Order of Council dated June 24, 1920, to be members of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research.

To deal efficiently with the greatly extending business of Davy Brothers, Limited, the directors have constituted a board of management comprising the following heads of departments, who each hold a substantial share qualification:—Mr. A. J. Capron (chairman), Mr. T. W. Hand (chief engineer), Mr. C. A. Mills (works manager), Mr. Sydney Smith (commercial manager), Mr. J. A. Sanderson (estimating engineer), Mr. F. Appleyard (engineer), Mr. C. E. Astwood (boiler works manager), and Mr. John B. Bardsley (secretary).

MR. A. M. KENNEDY, managing director of the Northumberland Shipbuilding Company, Limited, has been elected managing director of the Fairfield Shipbuilding and Engineering Company, Limited, Glasgow, in succession to Sir Alexander Gracie. Mr. Kennedy will retain his position as managing director on the board of the Northumberland Company. Mr. Cleghorn, who for fifteen years has been manager of the engineering works at Fairfield, is retiring owing to the state of his health. Mr. Cleghorn also retires from the board of directors, but his services are to be retained by the company in a consultative capacity.

Applications for Patents.

The names of communicators are printed in Italic type. A new number will be given when the Complete Specification is accepted.

Adaptable Moulding Machine Company and O'Keefe, W. M. Foundry moulding machines. 15,186, 15,187. June 4.

Alldays & Onions, and Black, R. H. Apparatus for charging blast-furnaces, foundry cupolas, etc. 13,119. May 12.

Allis Chalmers Manufacturing Company. Controlling flow of ore in roasting furnace. 13,786. May 19.

Aluminium Works and Santiago M.C. Moulds for casting aluminium, etc., pans, etc. 12,385. May 4.

American Smelting & Refining Company. Bar-stacking machines, etc. 15,122. June 3.

August, J. R. C. Furnaces for heating or annealing wire, etc. 13,016. May 11.

Beardsley, E. O., and Piper, W. F. Machines for making foundry moulds. 15,638. June 9.

Brack, J. Rotary furnaces for smelting, etc. 14,884. June 1.

Brookfield, D. Oil-sand for preparation of foundry cores. 13,370. May 14.

Budd, E. G. Method of annealing metals. 13,899. May 20.

Budd Manufacturing Company, E. G. Sheet-metal stamping-dies. 15,319. June 7. (United States, February 13, 1918.)

Caspersson, K. A. Alloys of iron. 15,007. June 2.

Cave, G. H. Crucible, etc., furnaces. 14,903. June 1.

Coles, S. O. Cowper-. Electro-deposition of iron alloys. 12,662. May 7.

Cornelius, C. E. Producing zinc or zinc and lead. 14,484. May 27.

Cotterill, Limited, F. W. and Marson, R. Nut-forging machines. 15,248. June 5.

Davies, E. W. Apparatus for automatic manipulation of metal ingots, etc., at rolling-mills. 12,594. May 6.

Dawson, W. A. Device for pulverising minerals, etc., regrinding, grading, and treating resultant products. 14,818. June 1.

Dayton-Wright Company. Method of joining metals. 15,964. June 12. (United States, June 30, 1919.)

Doehler Die Casting Company. Casting-machines. 14,120. May 21. (United States, March 19, 1918.)

Doehler Die Casting Company. Casting-apparatus. 14,121. May 21. (United States, August 10, 1917.)

Evans, G. Casting solid and hollow brass and copper billets. 15,870. June 11.

Evans, G. Manufacture of weldless metal tubes. 15,977. June 12.

Evans, I. B. Regulating-valves for gas-producers, furnaces, etc. 14,959. June 2.

Félizat, G. L., and Guignard, G. P. Destructive distillation of schists, shales, etc. 12,951. May 10. (France, April 12, 1919.)

Gill, A. T., and Thomson, A. Drilling, etc., machine. 14,635. May 28.

Gregory, J. Manufacture of iron, steel, manganese, ferro-manganese, etc. 14,631. May 28.

Inshaw, G. R., and J. G. Apparatus for cooling mandrels upon which hollow blooms are pilgered or rolled, etc. 13,163. May 12.

Klinkenberg, A. Manufacture of refined steel. 14,698. May 29. (Germany, July 3, 1918.)

Lane, H. M. Manufacture of foundry cores and dry sand moulds. 12,363. May 4. (United States, December 26, 1913.)

Mackay, P. A. Extraction of tungstic acid or tungsten trioxide from tungsten ores. 12,957. May 10.

Marks, A. Malleable cast iron. 13,390. May 15.

Oldfield & Schofield Company. Jolt machines for iron-founders. 12,163. May 3.

Ralph, G. J. Electric furnaces. 12,481. May 5.

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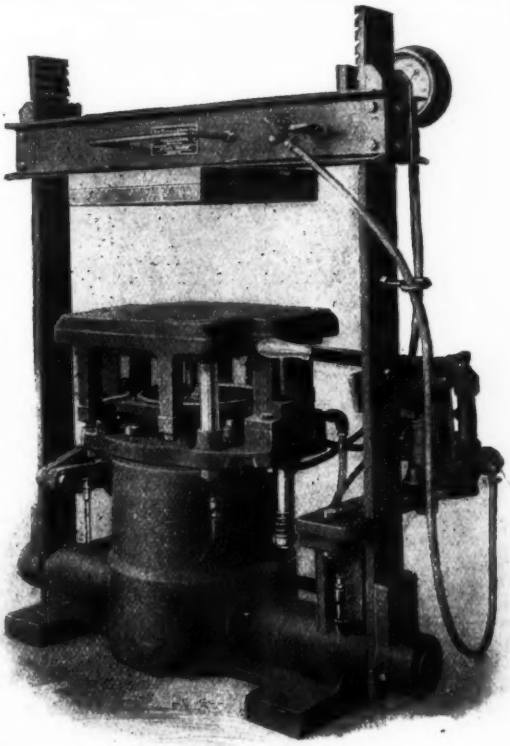

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Skatteboe, J. G. Producing cast-metal chains. 12,930. May 10.

Turnbull, C. Casting metals. 11,529. April 26.

Utard, A. Foundry moulding-machines. 12,357. May 4. (France, September 26, 1913.)

United Brassfounders & Engineers, Limited. Pressure gauge. 13,865. May 26.

Unruh, W. von. Process of treating steel wire. 14,697. May 29. (Germany, February 9.)

Varet, E. E. Lathes. 13,535. May 17. (France, May 17, 1919.)

Waddington, G. G. Manufactured steel products. 11,867. April 29.

Walter, R. Alloys of metals of the ferro-chromium group and silicum or its compounds. 12,386. May. 4. (Germany, January 7.)

Walter, R. Method of producing alloys with metals of the ferro-chromium group and silicum or its compounds. 12,387. May 4. (Germany, January 14.)

Walter, R. Method of producing alloys with metals of the ferro-chromium group and silicum or its compounds. May 5. 12,466. (Austria, March 20 1918.)

Parliamentary Notes.

Trade Combinations.

COLONEL NEWMAN asked the Prime Minister whether his attention had been called to the recent passing under foreign control of British firms; whether any licence or sanction of a Government Department had first to be obtained; and, if not, whether danger of unfair competition to the small trader and monopoly and consequent high prices to the public rendered some safeguard advisable.

MR. KELLAWAY said that the Department had seen a statement of the particular transaction to which the hon. member referred, but no licence or authorisation was necessary. As regards the last part of the question, the Board of Trade would watch developments of the kind carefully and take any necessary action.

Pig-Iron Shortage.

MR. MURRAY MACDONALD asked the President of the Board of Trade recently whether he was aware that the crisis due to the shortage of foundry pig-iron in Scotland still continues, and in an aggravated form; that, notwithstanding the steps now being taken, the quantity of English pig-iron available for Scotland has since been materially reduced, instead of being increased; that the Scottish ironfounders are being forced to place contracts for American pig-iron at a cost almost 50 per cent. more than that of English pig-iron; and, if so, whether he can indicate what further steps will be taken to secure an increase in the output of foundry pig-iron from the English blast furnaces?

SIR R. HORNE: I am aware of the general conditions indicated in the question, which are causing me serious concern. I have met the ironfounders and the ironmasters in conference, and am satisfied that the latter are doing all in their power, by restriction on export and by increased production, to meet domestic requirements, but they are encountering serious difficulties, which can only be overcome gradually.

In reply to a further question on the same subject, MR. BRIDGEMAN said that he had stated on several occasions recently that there was undoubtedly a serious shortage of pig-iron, which was affecting a number of industries. He was in constant communication with the producers of pig-iron on the subject, and there was no reason to think that the export was an important factor in bringing about the shortage, since it was being voluntarily restricted in those classes of pig-iron which the British trade required. He was satisfied that the iron masters were doing all in their power, by restriction on export and by increased production, to meet domestic requirements.

Deaths.

THE death is reported at the age of 70 years, of Mr. W. R. Mellish, who was at one time secretary of the London Metal Exchange.

MR. P. MCNAB INGLIS, the last surviving son of the founder of A. & J. Inglis, Limited, engineers and shipbuilders, Glasgow, has died in Glasgow.

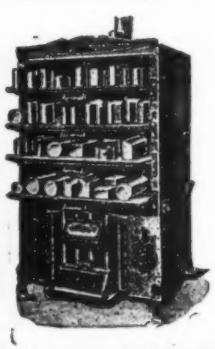
MR. J. H. JOSE, J.P., for many years technical adviser to the Bristol Channel Engineers' and Shipbuilders' Employers' Association, died recently at the age of 63 years.

MR. T. LLEWELLYN DAVIES, who has died at Middlesbrough-on-Tees, aged 64, had been for over 30 years manager of one of the establishments of Bolckow, Vaughan & Company, Limited, but retired in 1914.

THE death is announced, from Paris, at the age of 81, of M. Adolphe Carnot, the well-known mineralogist, and member of the Academy of Sciences. The deceased gentleman had held various Governmental and professional posts in connection with mining engineering, and had written several books on the same subject.

MR. W. F. FAIRLIE, managing director of the Forth Shipbreaking Company, Limited, Bridgeness, near Bo'ness, died at his residence, Seamore, on June 18. Mr. Fairlie, who was a native of the West of Scotland, went to Bo'ness 16 years ago, at which time the Bridgeness yard was opened. Under his skilful management the business prospered and important extensions were carried out. He was 64 years of age.

MR. E. G. SPILSBURY, president of the E. G. Spils-



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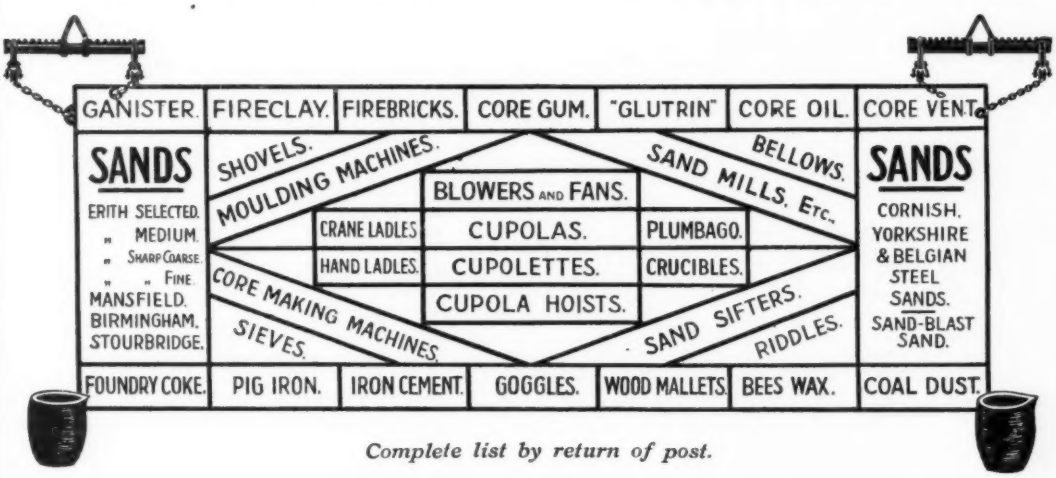

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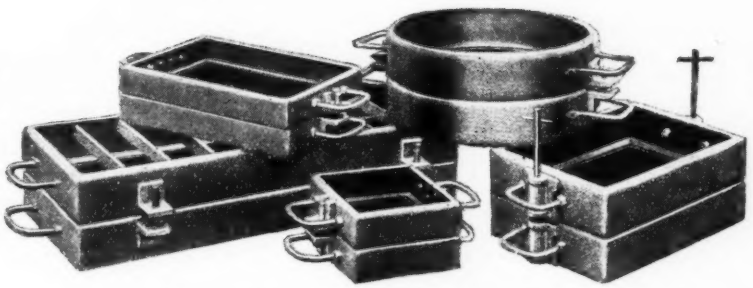

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bury Engineering Company, and former president of both the Engineers' Club of New York, and the American Institute of Mining and Metallurgical Engineers, died suddenly on May 28, in New York. He was 75 years old, having been born in London in 1845. He went to the United States to investigate the supply of lead and zinc, becoming manager of the Trenton Iron Company in 1888.

MR. J. W. W. DRYSDALE, of the Bon-Accord Works, Yoker, died recently at the age of 71 years. Mr. Drysdale was well known in Glasgow, and specially in engineering circles. In conjunction with Mr. L. J. Pirie, of Aberdeen, he commenced business in Bridgeton in 1874, as makers of centrifugal pumps, and subsequently, through necessary extensions required, the company, as Drysdale & Company, Limited, removed to Yoker, where the deceased gentleman continued as managing director.

MR. JAMES WEIR, one of the founders of the firm of G. & J. Weir, Limited, Holm Foundry, Newlands Road, Cathcart, Glasgow, and father of Lord Weir, has died at Lockerbie, aged 78. The deceased gentleman started business in Liverpool, and later in Glasgow. He early recognised the necessity for the use of fresh water on board ship, and was the first to place on the market a means for its production for marine purposes. In 1897, in conjunction with his brother, he founded the present extensive engineering works at Cathcart. He was the author of several notable works, was one of the founders of the Institute of Marine Engineers, and a member of the Institution of Naval Architects and the Institution of Engineers and Shipbuilders in Scotland.

New Companies.

Cutters & Tools, Limited.—Capital £12,000 in "A" shares of £1 and "B" shares of 1s.

Treforest Tinplate Company, Limited. — Capital £20,000 in £1 shares. Registered office: Treforest, Glam.

William Muirhead, Limited.—Capital £75,000 in £1 shares, to carry on the business of iron and steel merchants.

John Perks & Sons (1920), Limited.—Capital £200,000 in £1 shares, to carry on the business of edge tool makers.

Castleton Electric Company Limited. — Capital £125,000 in £1 shares (50,000 6 per cent. cumulative preference).

Morris (Engineers), Limited.—Capital £7,000 in £1 shares. Registered office: Bagnall Street, Great Bridge, Staffs.

Clayton Valve Company, Limited.—Capital £15,000 in £1 shares. Registered office: 75, Preston Old Road, Marton, Blackpool.

Components Castings Company, Limited.—Capital £600 in £1 shares. Registered office: 388, Park Road, Hockley, Birmingham.

Choughs Engineering Company, Limited. — Capital £5,800 in £1 shares. Registered office: Salt House Lane, West Hendford, Yeovil.

Falkirk Iron Company, Limited.—Capital £250,000 in £1 shares, to acquire the business of the Falkirk Iron Company, Limited.

North Wales Engineering Company, Limited. — Capital £25,000 in £1 shares. Registered office: 2, Exchange Court, Liverpool.

Clegg Foundry Company, Limited.—Capital £10,000 in £1 shares. Registered office: Royal Iron Works, Goulborne Street, Keighley.

Dartford Engineering & Carriage Company, Limited.—Capital £25,000 in £1 shares. Registered office: Hythe Street, Dartford, Kent.

North-Western Engineering Company, Limited.—Capital £20,000 in £1 shares. Registered office: 167, Lord Street, Fleetwood, Lancs.

Bute Wheel & General Engineering Company, Limited.—Capital £6,000 in £1 shares. Registered office: 57, James Street, Cardiff.

Ellison Bros., Limited.—Capital £6,000, to carry on the business of mechanical engineers at Bradford. Directors: A. Ellison and F. Ellison.

Torque Electrical and Engineering Company, Limited.—Capital £5,000 in £1 shares. Registered office: Salubrious Passage, Swansea.

Fred H. Pickering, Limited.—Capital £10,000 in £1 shares, to carry on the business of engineers. Registered office: 6, Stanley Street, Bury.

Dynamo and Motor Repairs, Limited.—Capital £10,000 in £1 shares. Registered office: Mapesbury Works, Willesden Lane, Kilburn, N.W.

Joseph Steel and Sons, Limited.—Capital £30,000 in £1 shares, to carry on the business of spring makers. Registered office: Harden, nr. Bingley, Yorks.

R. & J. Smith Brothers, Limited.—Capital £40,000 in £1 shares, to carry on the business of iron merchants. Registered office: Bridge Street, Sheffield.

Wulfruna Engineering Company (1920), Limited. — Capital £15,000 in £1 shares (2,500 preference). Registered office: Great Brickiln Street, Wolverhampton.

James Marshall Rochdale, Limited.—Capital £5,000 in £1 shares, to carry on the business of iron merchants. Registered office: 19, Oldham Road, Rochdale.

John & Abel Lees Dobb, Limited.—Capital £20,000 in £1 shares, to carry on the business of engineers. Registered office: Keb Lane, Bardsley, near Ashton-under-Lyne.

Joseph Wordsworth & Sons, Limited.—Capital £20,000 in £1 shares, to carry on the business of wire manufacturers. Registered offices: Owlerton Wire Mills, Sheffield.

T. J. Fairey (Kettering), Limited.—Capital £12,000 in £1 shares, to carry on the business of iron and brass founders. Registered office: 28, Dalkeith Place, Kettering.

Baburizza & Company, Limited.—Capital £50,000 in £1 shares, to carry on the business of machinery manufacturers. Registered office: Devonshire Chambers, 146, Bishopsgate, E.C.

Southgate (Birmingham), Limited.—Capital £3,000 in £1 shares, to carry on the business of brass finishers and founders, etc. Registered office: 56 and 58, Brearley Street, Birmingham.

Vickers-British East Africa, Limited.—Capital £2,000 in £1 shares. First directors: Sir Francis Barker, S. V. Dardier, and N. Robinson. Registered office: Vickers House, Broadway, Westminster.

Border Engineering Contractors, Limited.—Capital £3,000 in £1 shares. First director: D. H. Johnston (managing director). Registered office: 62, Church Road, Harrington, Cumberland.

Mid-Tyne Patternmaking Company, Limited.—Capital £2,000 in £1 shares. First directors: P. L. Goode and T. W. Marshall. Secretary: G. L. Goode. Registered office: Glen Street, Hebburn-on-Tyne.

Hemmings & Company (1920), Limited. — Capital £250,000 in £1 shares, to take over the business of steel manufacturers carried on by Hemmings & Company, Limited, at Valley Work, Grange Lane, near Sheffield.

Midland Counties Electrical Engineering Company, Limited.—Capital £3,000 in £1 shares, to take over the business carried on at Smethwick as the Midland Counties Electrical Engineering Company. Registered office: 136, Sandon Road, Smethwick.

Cudworth & Johnson, Limited.—Capital £10,000 in £1 shares, to take over the business of engineer, iron and brass founder, etc., carried on by executrix of late W. E. Johnson, at Wrexham, Denbigh. Registered office: Eagle Foundry, Wrexham.

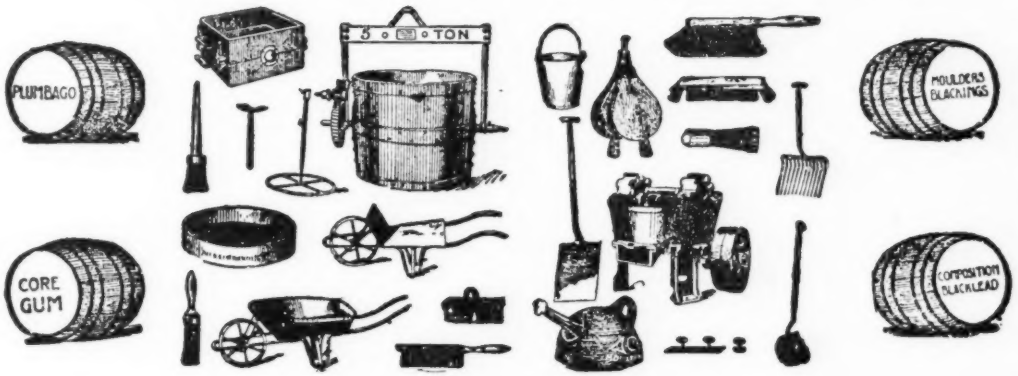
Wilcox & Lines, Limited.—Capital £2,500 in £1 shares, to take over the business carried on by R. H. A. Lines and B. J. Upton as Wilcox & Lines, at 85, Vittoria Street, Birmingham, and to carry on the business of hot brass stampers, etc.

Telephone: 21, Pennistone. Telegrams: "Durrans, Pennistone."

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



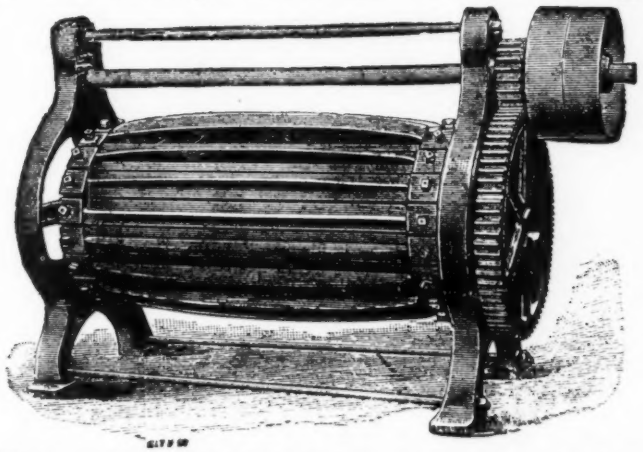
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

The Kilmarnock Foundry Company, Limited. — Capital £50,000 in £1 shares, to adopt an agreement with Grant, Ritchie & Company, Limited, and the North British Diesel Engine Works, Limited. Registered office: South Street, Whiteinch, Glasgow.

Monks & Crane, Limited.—Capital £2,500 in £1 shares, to take over the business of a file manufacturer and grinder carried on at Birmingham by E. D. Monks. First directors: E. D. Monks and E. Crane. Registered office: Star File Works, Cotteridge, Birmingham.

Amalgamated Stampers, Limited.—Capital £600,000 in £1 shares, to take over the business of the Smethwick Stamping Company, and the business of Armstrong, Stevens and Sons, Limited. First directors: Sir John Henderson Stewart. Bart., and A. H. Wild.

Webb & Lewis (Engineers), Limited. — Capital £4,500 in £1 shares, to take over the business carried on by G. H. Webb & Company, at Bissell Street, Birmingham, and to carry on the business of general engineers, etc. Registered office: 14, New Street, Birmingham.

Derby Aluminium Casting Company, Limited. — Capital £5,000 in £1 shares (2,000 pref.), to take over the business carried on by C. F. Green, of Whiston Street, Derby, as the Derby Aluminium Castings Company. First director: C. F. Green. Registered office: Whiston Street, Derby.

Fred. Price & Company (1920), Limited. — Capital £50,000 in £1 shares, to carry on the business of electrical engineers and contractors, etc. First directors: Sir Edward Nichol, Sir Wm. Diamond, R. Lane, and C. W. King. Secretary: T. C. Evans. Registered office: Institute Lane, Park Place, Cardiff.

Munro's Shipbuilding, Repairing & Engineering Company, Limited.—Capital £50,000 in £1 shares, to acquire the business carried on upon the Island of Kerrera at Oban by John Munro, Limited. First directors: H. Morton, J. Munro, D. W. Munro, and J. T. Mumme. Secretary: D. Graham. Registered office: Craigard Road, Oban.

Alnwick Foundry & Engineering Company, Limited.—Capital £20,000 in £1 shares, to take over the business carried on at Alnwick as the Alnwick Foundry & Engineering Company, Limited. First directors: J. Kean, M. A. Sell, E. Johnson, and A. Lennox. Secretary (pro tem): R. Sibbitt. Registered office: The Works, Stonewall Lane, Alnwick.

David Harcourt, Limited.—Capital £15,000 in £1 shares, to take over the business of manufacturers of chains and components, originally established about 1823 by David Harcourt, and until recently forming a branch of Harcourts, Limited, at Moseley Street, Birmingham. B. W. Harcourt (Sutton Coldfield) is permanent governing director.

James Barton & Son, Limited.—Capital £4,500 in £1 shares, to carry on the business of engineers as formerly carried on by J. Barton at Brown Road Engine Works, Sunderland, as J. Barton & Son. First directors:—J. Barton (permanent), J. D. Martin, G. Forsyth. Secretary, A. J. Ingramo, junr. Registered office: Brown Road, Fulwell, Sunderland.

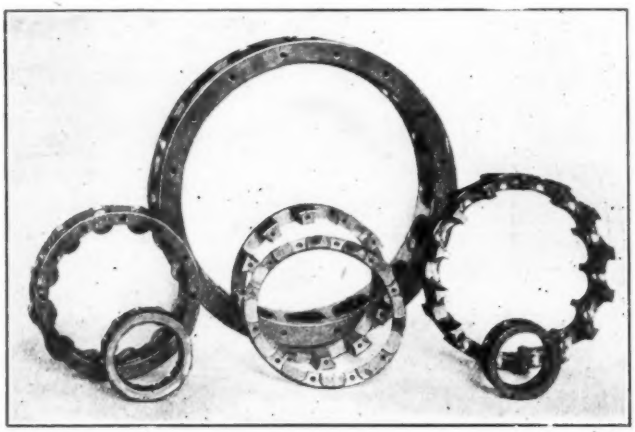
Irvine's Shipbuilding & Dry Docks Company, Limited. —Capital £740,000 in £1 shares (300,000 8 per cent. cumulative preference), to acquire the existing business. First directors: Rt. Hon. Viscount Furness, Sir John Esplen, C. C. Hatry, F. W. Lund, P. Haig-Thomas, R. A. Workman, A. S. S. Purdon, and S. J. Passmore. Secretary: C. G. Bowyer. Registered office: 6, Austin Friars, E.C.

H. & C. Grayson, Limited.—Capital £1,064,000 in £1 shares (816,000 preference and 248,000 deferred), to acquire the existing business. First directors: Lt.-Col. Sir Hy. M. Grayson, M.P. (chairman); D. H. H. Grayson, G. L. Bevan, S. J. Passmore, C. C. Hatry, G. A. Harradon, P. Haig-Thomas, J. R. Smith, G. H Potter, and F. G. Thompson. The first five named are permanent. Registered office: 6, Austin Friars, E.C.

JUST THINK whether your manufacturers include any intricate parts like these. If so, write us now.

These were Die Cast on a **Monometer Die-Casting Machine**

Dead to a Thou' by a leading Midland Firm.



The ONLY **REAL** Pressure Die-Casting Machine.

Sole Makers:—

MONOMETER MFG. CO. (1918), LD.

SAVOY HOUSE, STRAND. - - LONDON, W.C.2.

See these and all types of HARDENING & MELTING FURNACES at our

STAND No. 162, CRYSTAL PALACE EXHIBITION.

WE SUPPLY **THE** LEADING FIRMS IN THE TRADE WITH

FOUNDRY BLACKINGS

OF ALL KINDS

COAL DUST, CHARCOAL, PLUMBAGO and BLACK-LEAD CORE GUMS and all Foundry Requisites, and have done so since 1831.

I. & I. WALKER, EFFINGHAM MILLS, ROTHERHAM.

Our Specialite is Studying Special Requirements.

KINDLY HAND US YOUR ENQUIRIES.

The Mastery

of the Air.

FANS

SEND US YOUR ENQUIRIES FOR

are always successful in the struggle for the Mastery of the Air

Ventilation of Ships, Buildings and Mines, Induced Draught on Boilers, Dust Removal, High Pressure Fans for Forge Fires and Cupolas, Air Washers for Cooling and Purifying the Air, Fans for Removing Fumes or Steam, Steam Heater Units for Heating Factories and Workshops.

Davidson & Co., Limited, *Sirocco Works,* **BELFAST.**

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,

FIRE CLAY.

Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

J. GRAYSON LOWOOD & Co., Ltd.,

DEEPCAR nr. SHEFFIELD.

Telegrams: "LOWOOD, DEEPCAR."

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

Pig-Iron.

	Home £ s. d.
Hematite—	
East Coast Mixed Nos.	13 0 0
East Coast No. 1	13 2 6
West Coast Mixed Nos.	14 15 0
Scottish Mixed Nos.	14 5 0
Welsh Mixed Nos.	14 0 0
Cleveland—	
No. 1	11 10 0
No. 3 foundry G.M.B.	10 17 6
No. 4 foundry	10 17 6
No. 4 forge	10 17 6
Basic	11 7 6
Derbyshire, Leices., and Notts—	
No. 4 forge	12 0 0
No. 3 foundry	12 5 0
No. 2 foundry	12 7 0
No. 1 foundry	12 9 0
Basic	12 5 0
Northamptonshire—	
No. 4 forge	11 10 0
No. 4 foundry	11 11 6
No. 3 foundry	11 12 6
No. 2 foundry	11 14 0
No. 1 foundry	11 15 0
Basic	12 0 0
South Staffordshire, Shropshire and Worcestershire—	
Part-mine forge	12 2 6
Part-mine foundry	12 5 0
Common Staffs.	10 15 0
All-mine forge	12 15 0
All-mine foundry	13 0 0
Warm-air forge	13 12 6
Warm-air foundry	14 2 6
Cold blast	17 0 0
Basic	12 5 0
Scottish—	
Foundry, No. 3	13 5 0
Delivered in Manchester—	
*Derbyshire, No. 3	—
*Cleveland, No. 3	—
*Scottish, No. 3	—
* Merchant prices.	
Delivered in Sheffield—	
East Coast hematite	—
Derbyshire basic	—
Lincolnshire basic	—
Do. No. 3 foundry	—
Do. forge	—

High-Speed Tool Steel.

	s. d.
Finished bars, 14 per cent. Tungsten	3 6
Finished bars, 18 per cent. Tungsten	4 3
Per lb. delivered buyers' works.	
Extras—	
Rounds and squares 3 in. to 8 in. inclusive	4d. per lb.
Rounds and squares under ½ in. to ¼ in.	3d. ,,
Flats under 1 in. by ½ in. to ¼ in. by ¼ in., and all sizes over four times 3 in width and over thickness	3d. ,,
Bevels of approved sizes and sections	6d. ,,
If in Coils	3d. ,,
Packing	4s. per cwt
Bars cut to length	10% extra
Scrap from High-Speed Tool Steel—	
Scrap pieces, 5d.	
Turnings and Swarf, 3d.	
Per lb. net, d/d steel-makers' works.	

Ferro-Alloys.

Ferro-Titanium—23/25% Ti. carbonless, 1/10.
Ferro-Tungsten.—75/80%, 3/3.
Ferro-Molybdenum.—70/80% Mo., 10/-.
Ferro-Vanadium.—35/40%, Va., 67/6.
Metallic-Manganese.—98/99% carbonless, 4/-.
(All per lb.).
Ferro-Phosphorus—20/25%, P. £50 0 0.
Ferro-Chrome.—4/6%, car., £46 0 0.
Ferro-Chrome.—6/8%, car., £44 0 0.
Ferro-Chrome.—8/10%, car., £42 0 0.
Ferro-Chrome—Specially refined, basis 60% chr., max. 2% car., £94 0 0.
Ferro-Silicon.—45/50% Si., £23 10 0 d/d. at Sheffield Steelworks.
Ferro-Manganese.—80%, £37 loose, £38 packed. Export £45, according to destination.
(All per ton.)

Copper.

	£ s. d.	£ s. d.
Standard cash	92 0 0	92 5 0
Three months	94 5 0	94 7 6
Electrolytic	108 0 0	114 0 0
Tough	106 0 0	107 0 0
Best selected	107 0 0	108 0 0
Sheets	164 0 0	—
India	165 0 0	—
American electrolytic spot	114 0 0	—
Do. Sept.	114 0 0	115 0 0
Official average price cash, June		88 0 9
Do. Three months, June		90 15 1½
Do. Settlement, June		87 18 7½
Do. Electro, June		104 11 4½
Do. B.S., June		102 4 5½
Average spot price, copper, June		87 17 6
Do. Electro, June		101 18 2½

Tin.

	£ s. d.	£ s. d.
Cash	267 0 0	267 10 0
Three months	271 0 0	271 10 0
English	267 0 0	—
Bars	269 0 0	—
Refined	—	—
Straits	—	282 0 0
Australian		272 0 0
Eastern		292 0 0
Banca		268 0 0
Official average price, cash, June		250 18 6½
Do. Three months, June		255 10 6½
Do. Settlement, June		250 14 6½
Average spot price, June		250 16 1½

Spelter.

	£ s. d	£ s. d.
Ordinary	41 15 0	—
Remelted	36 0 0	37 0 0
Hard	26 0 0	28 0 0
Electro 99.9	48 10 0	—
English	43 10 0	—
India	36 0 0	37 0 0
Zinc dust 92 94%	85 0 0	90 0 0
Do. English	—	—
Zinc ashes, per cent. 70%	10 0 0	11 0 0
Official average price, June		42 2 11½
Average spot price, June		41 2 8½

Lead.

Soft foreign (net)	37 0 0
English	39 0 0
Official average price, June	35 1 4½
Average spot price, June	34 6 7

Antimony.

English regulus	60 0 0 63 0 0
Chinese	48 0 0 49 0 0
Crude	40 0 0 42 0 0
Ore	Nominal.

Aluminium.

Virgin Metal 98/99— 165 0 0 per ton.

Phosphor Bronze.

Ingots.	Per ton.
Alloy No. I. or II.	—
III., IV., or V.	—
IV. or VII	—
VIII.	—
XI.	—
Cast Strips and Ingots	—
Castings.	**Per lb.**
I. or II.	—
III., IV. or V.	—
IV. or VII.	—
VIII.	—
XI.	—
No. VII., Chill, Cast, Solid Cored Bars	—

Delivery 2 Cwt. free to any town.
10 per cent. Phosphor Copper price of best selected copper. £40 above
15 per cent. Phosphor Copper price B.S. £50 above
Phosphor Tin (5 per cent.) £30 above price of English Ingots.
Phosphor-bronze prices supplied by CHARLES CLIFFORD AND SON, LIMITED, FAZELEY STREET MILLS, BIRMINGHAM.

*Chromium (Metallic).

98/99— purity, per lb. 7/6

*Nickel.

In cubes, 98/99— purity per ton £230 0 0

Nickel Silver.

	per lb.
Ingots for raising	1/7 - 2/-
Ingots for Spoons and Forks	1/7 - 2/-
,, rolled to spoon size	1/10 - 2/3

*Tungsten Metal Powder.

	per lb.
96/98— purity	3/10½

*Molybdenum Metal.

96/98— purity, per lb —

*Cobalt Metal.

97— purity, per lb. £ 0 13 0

Quicksilver.

75 lb. bottle £ 20 10 0
* Net, delivered Sheffield Works.

Scrap Iron and Steel.

Cleveland.	s. d.	s. d.
Steel scrap, heavy melting	—	220 0
Iron scrap cast (cupola metal)	—	220 0
(London f.o.b.).		
Heavy steel		—
Light ,,		—
Heavy cast		—

Steel Scrap.

Without Analysis—	Per ton. £ s. d.
Heavy steel melting scrap	11 5 0
Steel planings, turnings and borings	9 15 0
Steel planings, turnings and borings mixed with wrought-iron or other material	9 10 0
Other classes of steel scrap, whether or not mixed	9 15 0
F.o.r. or in barge at nearest siding or wharf.	
With Analysis—	
Heavy steel melting scrap not over 0.04 per cent. p. and s.	11 10 0
Heavy steel melting scrap not over 0.05 per cent. p. and s.	11 10 0

Wrought-Iron Scrap.

	£ s. d.
(1) (a) W.I. plates and sections, not less than ¼ in. thick, reasonably clear of rivets, flanged ends, etc., suitable for shearing; cable scrap and chain scrap not less than ½ in. dia.	11 10 0
(b) Heavy W.I. scrap not less than ¼ in. thick including horseshoes, rivets and bolts, and scrap therefrom	11 10 0
(c) W.I. scrap under ¼ in. thick, and all W.I. scrap not included in classes 1, 2 and 3.	11 10 0
(2) Mixed W.I. scrap	10 0 0
(3) Wrought-iron planings, turnings and borings mixed with steel or other materials	8 10 0
(4) W.I. planings, turnings and borings	8 12 6

Cast-Iron Scrap.

	£ s. d.
Heavy ord., broken, between 1½ cwt. and 10 cwt. each	10 10 0
Heavy machinery, broken between 1½ cwt. and 10 cwt. each	10 15 0
Cold blast, broken, between 1½ cwt., and 10 cwt.	12 0 0
Ingot mould, unbroken	11 5 0
Do. broken, between 5 cwt. and 2 tons each	11 10 0
Do. between 1½ cwt. and 5 cwt. each	11 15 0
Railway chairs, whole or broken for remelting	10 5 0
Heavy lumps, not exceeding 2 tons each	9 17 6
Light	9 10 0
Burnt, broken ready for cupola	8 15 0
Burnt fire bars	9 5 0
Turnings and borings, for iron and steel makers	10 5 0

Old Metal.

London—	£ s. d.
Copper (clean)	74 0 0
Brass (clean)	50 0 0
Lead (less usual draft)	26 0 0
Tea lead	24 0 0
Zinc	23 0 0
New aluminium cuttings	120 0 0
Brazierv copper	61 0 0
Gunmetal	73 0 0
Hollow pewter	200 0 0
Shaped black pewter	105 0 0
(Above all d/d merchant's yard).	

Metallurgical Coke.

Durham and Northumberland—	£ s. d.
Blast furnace	3 2 9
Foundry	3 10 0
Lancs., Staffs., Yorks, Notts., Derbyshire, Lincolnshire and Midland Counties—	
Blast furnace	3 5 9
Foundry	3 17 9
F.o.t. at ovens.	